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Successful small towns and development challenges in the perspective of 2040

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Abstract: Small towns of up to 20 thousand inhabitants account for roughly 80% of towns in Poland. One can distinguish among them the ones that have achieved success in terms of socio-economic development. They are characterised by a positive course of the socio-economic processes, shaping the high level and quality of life of the residents and stimulating the development of the spatial structure, featuring the above-average achievements against the background of the population of towns in Poland. The purposes of this report are to identify and to characterise these towns of success and to attempt to cognise the opinions of their administrative authorities on the subject of selected development challenges, faced by them in the perspective of more than a dozen years to come. A set of diagnostic features was used to identify the success towns. The establishment of the opinions concerning the development challenges was performed on the basis of a questionnaire addressed at the representatives of urban authorities. The study has shown that the successful centres concentrate in the vicinities of a couple of regional capitals. The output from the questionnaire-based survey generally indicated the optimism of the representatives of the analysed towns, featuring a positive opinion to the direction of the proposed socio-economic and environmental trends and a positive opinion on the potential influence thereof on the town.

Keywords: small towns; tows of success; future development; Poland

Introduction

Recent decades brought fascination with the concepts of urban development, in which particular attention is paid to the use of the modern information technologies and to active participation of the inhabitants. Among these concepts one can mention, especially, the ideas of *smart-city*, *slow city*, *green city*, *sustainable city*, and *town of well-being*, to mention just a few. At present time, there is the idea of *smart-city*, which appeared yet before the year 2000, which seems to be the most popular. This idea assumes that a city makes use of the information and communication technologies for purposes of increasing the interactivity and effectiveness of the urban infrastructure and its

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components, and also in order to raise the awareness of the inhabitants (Giffinger et al. 2007). Over time, successive generations of the *smart-city* appeared – from the town inspired by the modern information and communication technologies, through the town that responds, first of all, to the needs of the residents, up to the town that takes advantage of the opportunities provided by sustainable development (Komninos 2008, UCLG 2012, Albino et al. 2015, Cohen 2015, Giffinger 2016). Studies devoted to the concept of an intelligent ("smart") city emphasise, usually, its four main qualities: sustainable development; modern technologies; compatibility; and flexibility (Singh et al. 2022). The concept of "smartness" found its reflection, as well, in the studies of rural areas, in the form of the *smart village* concept (Somwanshi et al. 2016).

Then, the concept of a *town of well-being* accounts, first of all for the social satisfaction, and the satisfaction from the fact of living in a definite town (Barton 2017, Gehl 2010). The rate of economic growth is not the most important issue in this context, but emphasis is placed on the satisfaction of the urban residents and on their feeling of well-being (Lovins and Cohen 2011). A particularly significant question in the studies concerning the *towns of well-being* is the maintenance of proportions in the land use and in internal transport-wise accessibility. It is from these prerequisites that the concept of the *15-minute city* has originated (Weng et al. 2019, Reimer 2020, Moreno et al. 2021). Another essential postulate, resulting from the concept of the *town of well-being*, is the development of good social relations in the healthy and clean natural environment (van Assen et al. 2017, Sim 2019, Abusaada and Elshater 2020, Capolongo et al. 2020).

It should be stressed out that the majority of the contemporary concepts of urban development are addressed at the large urban centres, and even at cities of a global character. Much less attention is paid to small towns, which, in general terms, are characterised by different development challenges (Lopes and Oliveira 2017, Ruohomaa et al. 2019). An exception, which accounts for this kind of challenge is the concept of local development *slow city* (or *cittaslow*), which is dedicated exactly to the small urban centres. Its premises refer, first of all, to the projects and investments that are friendly for the environment and for the residents, they are based on internal resources, and they guarantee a "place of good living" (Mayer and Knox 2006, Radstrom 2011, Brodziński and Kurowska 2021). The concept of *slow city* is sometimes treated as a philosophy of development and it is being used as a tourism-related quality (Ekinci 2014).

The superordinate objective of all the concepts mentioned above is to achieve a development success of the town, which, depending upon the adopted premises, concerns to a greater degree the inhabitants, or the economy, or definite elements of the urban space. *Success* is more of a journalistic than a scientific notion, and it has, in addition, a very broad spectrum of meanings. For some, success shall, therefore, consist in the attainment of a satisfactory level of life quality or of professional position; for other ones – achievement of common social objectives, decisive for the satisfaction of the community. The present study shows an attempt of cognition of

small towns, which achieved development success. Hence, considering the scope of each problem area, this notion clearly differs from the commonly understood success of an individual or a social group. It is, namely, necessary to consider, in the study of development of an urban centre, at least two fundamental elements of the involved complex structure, namely the society and the economy. Additionally, an important development is constituted by the state of the natural environment.

The study of the literature, mainly concerning spatial economy and regional development, indicates that scholars are more interested in the search for and diagnosing of the problem regions or areas, than in those that achieved a success. This is, most probably, the consequence of the fact that the areas which feature disadvantageous economic and social processes require special attention and intervention, stimulating the need for developing the diagnostic within strategic and forecasting documents. Still, quite some attention ought to be also paid to the areas which achieved success. These areas may not only provide a reference point to be attained but they do also exert advantageous influence on the neighbouring regions. This observation is confirmed by the fact that the areas of success are an unalienable element of the classical theories of regional development – the growth pole theory of Perroux (1955); the centre-periphery model of Friedmann (1969); and the regional classifications of Berry et al. (1976), and of Friedmann and Weaver (1979).

The cognitive objective of this study is to identify the small towns of success in Poland, and then to learn the opinions of the administrative authorities on the development challenges which these small towns face in the perspective of the coming dozen or more years. The study of this subject area was motivated by the wish to answer to the following questions:

1) *Are the small success towns located mainly in the vicinity of the large urban agglomerations, or do they also constitute specific local centres of development within the peripheral areas?*
2) *What directions of selected social, economic and environmental trends are most often indicated by the representatives of authorities of the success towns?*
3) *What will be the potential influence of the trends considered on the success towns in the perspective of the year 2040?*

The identification of towns which have achieved success was founded on the principle of inequalities in the generally conceived social and economic development, meaning that it was assumed that success is a relative phenomenon. A set of selected diagnostic features was used in the identification. And, in order to discern the opinions on the proposed development challenges, the results of a questionnaire-based survey, addressed at the representatives of the self-governmental authorities of the towns, were analysed. Three categories of trends were distinguished – social, economic and environmental – and assessed as to the possibility of their appearance and to their

potential influence on the town development in the perspective of the year 2040. The analysis was applied to all small towns (i.e. those with up to 20,000 inhabitants) in 2019, as based on the existing statistical material (Bański 2023).

The concept of successful towns

Areas of success may be defined and identified using static, dynamic or mixed perspectives. An instance of the statistical approach to success is provided by Perlín and Šimčíková (2008), in which success is achieved by the areas featuring rich social and cultural life, and a high intensity of the activity of the inhabitants. Similarly, Herbst and Piotrowska (2008) define success as the attainment of a high level of development across various spheres (life quality, public and private investments, entrepreneurship and social activity). In this case, the definitional discrepancy is expressed through the question of the range of spheres, which are subject to assessment. Scrutinizing the identification of success areas through a summary indicator, other studies operate under the premise that developmental success is the sum of the over-average achievements in the individual spheres. In contrast, Fosu (2013) and Satterthwaite (2016) argued that success in one sphere does not necessarily corelate with similar achievement in the remaining ones. It appears also that the static approach, within which the state of selected diagnostic features is usually analysed for a definite time, serves more the purpose of classification or assessment of the level of development of the territorial units than that of identifying the success. That is why the dynamic approach is applied more frequently in the measurement of success in which the object of scrutiny is the comparison of the rates of territorial unit development within a definite time interval (Gorzelak et al. 1999, Bański 2008, Sánchez-Zamora et al. 2014).

Not all scholars, however, share the opinion that an area of success has to feature an upward tendency. Fosu (2013), for instance, explains that successful areas have the right to undergo crises and to be subject to failures. This author emphasises that the critical premise which demonstrates success is the capacity of overcoming the difficulties. This viewpoint is also expressed by some other scholars. So, in particular, it can be concluded that a success is constituted by the overcoming of the critical situation (de Janvry and Sadoulet 2005). In addition, as maintained by Satterthwaite (2016), economic success does not necessarily translate into into success across other spheres.

The town of success may be defined, as well, from the point of view of expectations from the side of the town inhabitants or of the representatives of the urban authorities. The perception of success may result from the preferences of particular social groups, and so the vision of the town of success may vary quite a lot. In this case, an essential issue is to identify the conditions which shape the success of a territorial unit. Thus, for instance, van den Heiligenberg et al. (2017) undertook an attempt to identify factors influencing the achievement of success in terms of sustainable development in the

domain of food, mobility and energy. It turned out that the most important factor of success is the involvement of the users, followed by the cooperation in local networks, the dissemination of good practices and educational experiences, as well as the elaboration of the vision for the future. The latter element can be identified, in the case of territorial units, with the existence of a current development strategy.

Methodology

In the present study, it is assumed that the success of a territorial unit is determined both by the high level of socio-economic development (static approach), and by the positive course of the socio-economic processes (the dynamic approach). Hence, a successful town is characterised by the advantageous course of the socio-economic processes which contribute to the high level and quality of life of the inhabitants, and which stimulate or strengthen the development of the town's spatial structure, with the development in question displaying a clear over-average dynamic in relation to other urban centres. The identified factors of success in the form of endogenous (or exogenous) potentials allow for indication of the processes which are necessary for the given area to develop. The assessment of processes (the dynamic approach) makes it possible to determine which of them have a positive tendency, and which ones – to the contrary – are the evidence of degradation. So, the static approach and the relative assessment (reference to the base year and/or to other areas) allow to establish whether the success was achieved.

The research objectives were being achieved in two separate tasks. The first task involved the identification of small towns of success in Poland. For the purposes of this study, a small town was defined as any territorial unit possessing city rights and a population of fewer than 20,000 inhabitants. In the view of the fact that a rich repository of statistical materials was used (Bański 2023), the study refers to the year 2019, when there were 722 such towns in Poland. Since the required statistical materials were not available for 36 centres, these units were excluded the final analytical set consisted of 686 small towns.

The study adopted the six diagnostic features that were made use of, characterising demography, social activity, economic activity, technical infrastructure, housing economy, and social infrastructure. The diagnostic features were expressed in the form of the following indicators:

1) W_1 – change of the population number in the years 2011-2019 per 1,000 inhabitants;
2) W_2 – average electoral turnout in self-governmental elections in the years 2010, 2014 and 2018;
3) W_3 – number of businesses per 1,000 inhabitants in 2019;
4) W_4 – share of population using sewage network in 2018;
5) W_5 – change of the number of flats in the years 2010-2019 per 1,000 flats in 2010;

6) W_6 – number of children in the age of 3-6 years per one kindergarten in 2019 (negative impact).

The assumption was adopted that the towns of success shall be these centres which are characterised by at least five out of six indicators with values above the average for all of the small towns considered (Table 1). This means that the individual categories are treated on a par, but their values are not summed; instead, the fulfilment of the condition of exceeding a threshold is checked for a given indicator, leading to the assignment of the value of 0 (threshold not exceeded), or 1 (threshold exceeded). The application of this procedure led to the scoring based on the verified six properties. A qualified town could register a value lower than average on one variable, which agrees with the proposition of Fosu (2013), and Satterthwaite (2016), namely that a definite qualified unit does not have to be outstanding simultaneously in all considered spheres.

Table 1. Descriptive statistics for the analysed indicators in the set of the 686 small towns considered

Indicator	W_{Max}	W_{Min}	Average	2nd quartile
W_1	66.1	–16.7	–2.8	–3.8
W_2	0.7	0.4	0.5	0.5
W_3	1381.3	74.3	188.3	178.3
W_4	100	0	84.4	87
W_5	72.1	-5.1	5.5	4.2
W_6	413	0	82.8	72.4

Source: own elaboration on the basis of data from the Central Statistical Office

Thus, the condition of scoring 1 for a given indicator W_k, for an i^{th} town, is the fulfilment of the criterion, expressed as:

$$W_{ki} > \underline{W}_{kn} \tag{1}$$

where:

W_{ki} – value of the *k*-th diagnostic feature for the *i*-th town,

$\underline{W}_{kn}$ – arithmetic mean of the *k*-th diagnostic feature over *n* towns.

The towns which were qualified as success towns fulfilled the following condition:

$$\sum_{k=1}^{m} P_{ki} \geq 5 \tag{2}$$

where:

m – number of diagnostic features,

P_{ki} – score (0 or 1) of the *i*-th town on the *k*-th diagnostic feature.

The indicators W_1, W_2 and W_5 were meant to point out the centres which are characterised by the advantageous course of the demographic and socio-economic processes.

The remaining three indicators (i.e. W_3, W_4 and W_6) were of static character and they determined the level of town development at a definite time instant. The threshold values for each of the considered features were equal to the arithmetic mean for the set of the analysed units, and there were these values that should be exceeded on at least five counts by a town of success. Altogether, 94 centres fulfiled this condition, with 25 of them featuring over-average indicator values for all the six indicators.

Then, the identified towns of success were classified into size-based groups (up to 5,000 inhabitants; between 5,000 and 10,000 people; and more than 10,000 inhabitants), and into four morphological categories (settlement towns; industrial towns; respite towns; dichotomous towns), resulting from the analysis of land use (urbanised areas; green areas; residential areas; industrial and storage areas), which enabled an in-depth analysis of their structures (Bański et al. 2024).

The second task involved the analysis of opinions solicited from management representatives of small success town offices. This analysis focused on selected social, economic, and environmental trends projected to influence the development of their towns up to the year 2040[1]. For each of these three trend categories, a preliminary set of established trends was proposed. The choice of these trends resulted from discussions among the five researchers working on 2020-2024 project of the Polish Academy of Sciences, financed by the National Science Centre in Poland (*'Diagnosis of the contemporary socio-economic structure and functional classification of small towns in Poland – in search of model solutions'*). The questionnaire employed for this inquiry was designed to account for a broad spectrum of contemporary processes and phenomena observed within small towns across Poland. Moreover, the choice of a closed set of trends enabled the objective assessment of the opinions expressed by the participants of the inquiry with respect to a definite and comparable range of issues. Ultimately, responses were obtained from 31 successful towns. Since this sample represents 31 out of 94 units, the results may lead to a high maximum error and lack representativeness in the entire set of success towns. Despite this limitation, the reserchers determined that presenting and commenting on these findings was worthwhile, especially as some cases were highly precise, so deeper conclusions could be drawn from them.

Results and Discussion

The structure and the spatial location of small towns of success

The analysis of the six diagnostic characteristics indicated before enabled the identification of 94 success centres in Poland within the set of 686 small towns considered.

[1]Messages in electronic form, containing the questionnaire were addressed at the Town Secretary or Town and Municipality Secretary.

Among the success towns, the largest share went to the smallest towns, having up to 5,000 inhabitants (Table 2). Yet, this was primarily the simple consequence of the fact that these towns form the biggest group in the entire sample analysed. They account, namely, for close to half (47%) of all the small towns. Considering uniquely the group of the smallest towns, some 14% of them could be treated as success towns. In terms of this share, the best situation was with the small towns having between 10,000 and 20,000 inhabitants – 19% of them could be treated as success towns. This, in turn, was most probably the effect of a greater diversity and multiplicity of social and economic functions which they fulfil. An important share of them was, namely, constituted by the county seats, which were characterised by additional administrative and service functions, these functions contributing to and shaping the socio-economic development. The lowest share of the success towns was observed for those with a population between 5,000 and 10,000 people. Only 9% of them qualified as success towns.

Table 2. Small towns of success according to size and morphological classification

Characteristics		Total small towns	Small towns of success	Share (%) of small towns of success
Size classification (population number)	Up to 5,000	322	44	13.7
	From 5,000 to 10,000	184	16	8.7
	From 10,000 to 20,000	180	34	18.9
Morphological classification	Housing estate town	234	51	21.8
	Industrial town	248	27	10.9
	Respite town	136	11	8.1
	Dichotomous town	68	5	7.4

Source: own elaboration

The identified towns are characterised by a distinct regional concentration. They are, namely, located mainly in two provinces (NUTS2) – Mazowieckie and Wielkopolskie, primarily in the neighbourhoods of Warsaw and Poznan, as these two cities form extended metropolitan areas (Figure 1). A significant number of successful cities are also located around other large centres – Cracow, Lodz, Wroclaw and Rzeszow. The literature of the subject has been indicating these areas as the national cores of development, possessing the richest social, economic and infrastructural resources (Smętkowski et al. 2009, Bański 2010). The neighbourhood of a large centre of national or regional importance is conducive to the development of modern sectors of economy, and it gives rise to definite social and demographic structures. Owing to this, small towns located within the metropolitan areas are usually characterised by the migration inflow of well-educated and active persons. Other investigations confirm, as well, the existence of a distinct influence of the location of a small centre with respect to a large agglomeration on its functional structure and on the labour market (Jones et al. 2009,

Pateman 2011, Cox and Longlands 2016). In the case of satellite towns, more important are the functions resulting from the relations with the neighbouring agglomeration than the functions fulfilled with respect to the surrounding rural areas (Woods 2007, Vaishar and Zapletalová 2009, Bański et al. 2016).

Figure 1. Location of small towns of success according to their size category

There is a very limited group of success towns which are located far away from the regional centres. Among them, the biggest group is constituted by those having between 10,000 and 20,000 inhabitants, which confirms the previously expressed supposition that success is more easily achieved by the bigger centres, fulfilling additional administrative and service functions. An exception is constituted by the province of Wielkopolskie, where the spatial distribution of success towns is rather uniform.

Altogether, this province accounts for as much as 30% of all towns of success. It is only in the northern part of this province where, during the socialist period, the farming function played an essential role and it was dominated by the state sector, so no towns of success were identified. A similar regularity characterises the remaining areas of northern Poland. The lack of such centres in the eastern part of Poland is the effect of delay in development and of particularly disadvantageous demographic conditions. Eastern Poland has been for a long time characterised as a problem area, requiring the strategic intervention of the state (Śleszyński et al. 2017).

The largest proportion of successful small towns belongs to the category of settlement towns, which are characterized by a dominant residential function. Approximately one-fifth of towns within this classification are characterized by developmental success. This outcome is largely linked to the aforementioned concentration of these centers within metropolitan zones, where the majority of features analyzed exceed the respective averages established for all small towns across Poland. The remaining categories of success towns exhibit a lower degree of concentration as they are fewer in total number compared to the settlement towns. Thus, only around 11% of industrial towns qualify as success towns, while the other considered town types demonstrate even smaller shares. Among the category of respite towns, those primarily qualifying as successful display historically sustained tourist and recreation functions.

Developmental challenges in the opinion of town officials

In conformity with the previously provided information, the results from the study of opinions on the development trends in 31 towns are not representative for the whole group of success towns. Yet, for a couple of definite trends, the opinions of the representatives of towns are to such an extent unambiguous that they could be supposed to be sufficiently likely for all successful towns. Thus, for instance, regarding the social trends, the most pronounced opinions concern the increase in the share of digital society and its positive influence on town development (Table 3). Regarding the qualitative structure of the urban population of small towns, an improvement in their education level is expected, along with a stronger involvement in social life. All these phenomena should have a clearly positive impact on urban development. Similar expectations concern the increase in the expenditures for social purposes, but in this case the assessment of the process is rather negative, which may result from the limitation of expenses on other development goals. Still, in the opinion of almost all respondents (94%), there will be an improvement in the availability of social infrastructure in towns, and the effects thereof shall have a positive or rather positive influence (97%) on the development processes in the perspective of the year 2040.

In terms of demographic development, the opinion dominates that the number of inhabitants shall not decrease (*shall not* or *shall rather not*). This was the opinion of 64% the respondents. On the other hand, a distinct majority of respondents expect a further

Table 3. Opinions of town authority representatives on selected trends until the year 2040

Trends	Opinion on the social trends which can appear in the town					Opinion on how these trends, if appearing, shall influence the town				
	Responses [%]					Responses [%]				
	yes	rather yes	neither yes, nor no	rather no	no	+	rather +	shall not have influence	rather —	—
Social trends										
The number of inhabitants shall ↘	10	16	10	42	22	0	0	29	36	35
The share of the elderly in the urban population shall ↗	2	55	3	10	0	0	3	19	52	26
The number of young residents migrating away from the town shall ↗	10	29	35	16	10	6	16	19	26	32
Migrants from countries of Africa and Asia shall flow in	3	13	26	42	16	0	3	52	29	16
Expenditures on social needs shall ↗	35	61	3	0	0	0	26	29	39	6
The education level of the inhabitants shall improve	16	45	39	0	0	42	48	6	0	3
The share of digital society in the urban population shall ↗	32	68	0	0	0	48	42	3	6	0
The availability of social infrastructures shall improve	23	71	6	0	0	52	45	0	0	3
Political divisions among the inhabitants shall grow	16	10	52	19	3	0	0	42	26	32
Social involvement in participative projects shall ↗	10	26	58	6	0	35	42	16	3	3
Economic trends										
The autonomy of the town shall ↗	3	29	23	45	0	16	35	42	6	0
The spatial reach of the town influence shall ↗	13	29	26	32	0	13	58	29	0	0
The number of businesses shall ↗	10	48	28	10	3	45	45	6	0	3
Town budget revenues ↗	39	39	13	6	3	55	35	6	0	3
The number of jobs shall ↗	26	35	26	13	0	58	32	6	0	3
The sectoral diversity of available jobs shall ↗	10	35	39	16	0	42	39	19	0	0
The demand for energy shall ↗	35	48	6	10	0	6	6	32	52	3
The role of non-conventional energy sources shall ↗	23	65	6	6	0	32	58	10	0	0
The availability of technical infrastructures shall improve	23	65	3	10	0	55	42	3	0	0
The transport-wise accessibility of the town shall improve	29	48	16	6	0	55	42	3	0	0
The quality of spatial planning shall improve	26	61	6	6	0	58	42	0	0	0
Environmental trends										
The level of cleanliness of the natural environment shall ↗	10	65	23	3	0	48	39	13	0	0
The availability of the drinking water shall ↘	3	32	35	29	0	0	0	16	35	48
The effectiveness of waste management shall ↗	6	71	13	6	3	55	32	13	0	0
The role of extreme weather events shall shall ↗	19	55	23	3	0	0	0	16	48	35
The requirements on environmental protection shall get stricter	32	61	6	0	0	10	61	16	6	6

↘ – decrease, ↗ – increase, + – positive, — – negative

increase in the share of the elderly in the urban population, which should bring negative consequences for the town. The process of ageing in the towns considered was indicated

by close to 90% of respondents, with 32% being convinced that the process would certainly take place within the perspective of the year 2040. In the countries of Western Europe, it was already in the 1960s that a drop in birthrates occurred below the simple generation replacement, while in Central and Eastern Europe a similar phenomenon appeared in the 1990s (Lesthaeghe 2010). A more intensive growth of the share of the elderly in the population was observed in towns than in rural and peripheral areas (Hoff 2016, Rosenbers and Wilson 2018).

Ageing of the demographic structure in Polish small towns has been taking place for at least two decades and it is associated with both the phenomenon of outflow of young residents to large cities and the decrease of birthrates (Bański et al. 2023). In this context, it is significant that these negative processes are especially intensive in small, peripheral towns (Bartosiewicz et al. 2019). Expectation of a similar trend in the success towns, which are usually not located in the peripheries, is evidence that the representatives of the administrative authorities attach quite some importance to this phenomenon. Hence, one is not surprised by the clearly negative opinion as to the influence of this trend on the development of the town. The consequences of the respective process shall include the necessity of increasing expenditures on social needs, which was also very distinctly revealed in the questionnaire-based study.

The opinion on the potential outflow of young inhabitants to larger cities is differentiated, and the clear answers "yes" or "no" were obtained from only 10% of the respondents for each of these two cases. There is a relatively important group (35%) of respondents who expect that the process shall remain at a similar level as nowadays, but it is, anyway, being assessed negatively by the majority of the respondents. It is worth noting also that as many as 22% of respondents expressed a positive assessment of this process, while further 19% thought that it will not have an impact on the development of the town until 2040. This kind of attitude is, definitely, startling for the localities with a "young" age structure, as they usually feature a higher development potential. It is possible that this sort of view is based on the difficulties on the labour market which the young can encounter, or on other problems in satisfying the needs of the young people, including the degree of availability of appropriate social infrastructures in towns. During another study, carried out in small peripheral towns, the in-depth interviews with the young residents revealed that the biggest problems that this group faces are: the structurally narrow and very limited labour market; and the shortcomings with respect to the availability of the social infrastructure for serving their needs, which are related to spending the leisure time (Bański et al. 2023).

Particularly exploited in the media, the current popular theme of inflow of migrants from African and Asian countries is not a significant subject of interest of the authorities in small urban centres. A vast majority of the respondents stated that such a phenomenon should not appear or it rather should not appear in their localities. The assessment of this phenomenon is to a similar degree neutral or negative.

Regarding the proposed economic trends, the probability of their occurrence is high in the opinion of the majority of respondents. It should be noted, though, that the highest proportion of responses falls on "rather yes", demonstrating the lack of certainty among the respondents as to the occurrence of the given trend. The highest degree of agreement among the respondents concerns the increase of demand for energy, which is currently already one of the biggest challenges facing the entire world economy. Along with the increasing demand for energy, the structure of its production shall change. According to the forecasts of OPEC, the significance of oil in the global structure of energy sources shall decrease in the period 2014-2040, from 31% to 26%, and of coal – from 28% to 22%, while, at the same time, the role of gas shall increase from 22% to 26%, of nuclear power – from 5% to 7%, and of the renewable technologies – from 1% to 6%. The shares of hydropower and of bioenergetics technologies are expected to remain stable (Al-Yasiri 2022, International Energy Agency 2023). Yet, it is assumed for the countries of the European Union (EU) to attain already by the year 2030 the share of gross energy use from renewable sources of 42%. One is not surprised, therefore, by the opinion from a large group of representatives of small towns that the increase of demand for energy will bear a rather negative influence on the development of these towns. This will, namely, generate additional costs, and, first of all, the effort needed to comply with the requirements of the EU. Such an observation is also confirmed by the conviction of close to 90% of respondents as to the growing role of the non-conventional energy sources in small towns.

The high degree of optimism of the representatives of small towns is associated with the improved availability of technical infrastructure. This seems to be linked with the previously mentioned increase of demand for energy and the development of energy infrastructure, as well as the development of transport infrastructure. Close to 80% of the respondents expect an improvement in the transport-wise accessibility of the town. A similarly high optimism concerns the revenues of the town budget and improvement in spatial planning. Regarding the budgetary revenues, the expressed optimism is supported by the statistical data from the recent years, indicating a gradual increase in the budgets of all territorial self-governmental units, in which the primary role is played by their own revenues. Yet, when one considers the expenditures, the optimism would have to be restrained, for expenditures are usually higher than the revenues, leading generally to an increase in the urban debt.

The responses concerning the autonomy of the town and the spatial reach of its influence are more differentiated. A relatively large group of representatives of success towns expressed a negative opinion on the appearance of these trends, but this was not an unambiguously negative response. There were also essential doubts with respect to the two proposed trends related to the labour market – increase in the number of jobs offered and increase in the sectoral diversity in the structure of existing jobs. Another relatively large group of respondents (42%) expressed a neutral opinion as to

the role that might be played by the increase of the autonomy of the town in terms of development processes in the town. This may be an effect of the fact that the majority of success towns are situated in the vicinity of large agglomerations, which, explicitly or implicitly subordinate their satellite towns in terms of of economic conditions.

Concerning the trends in the environmental domain, the opinions of success town representatives are in the majority of cases conform to the currently applied environmental policies of the Polish administration and of the EU. There are, namely, expectations as to the increase of cleanliness of the natural environment and of the requirements as to environmental protection, as well as improvement of effectiveness in waste management. Relevant investigations confirm that an improvement of air quality in Polish towns is expected particularly due to the concept of "smart city". The areas of towns, first of all of the small ones, undergo nowadays the process of revitalisation of degraded surfaces, resulting from the enactment of the *Law on revitalisation*. In the context of the waste management economy, the most significant from the point of view of an inhabitant is the appraisal of cleanliness of the surrounding environment. Statistical data confirm that the volume of waste per inhabitant in Poland is increasing from year to year (according to the Central Statistical Office, by more than 12%, between 2017 and 2022), but the amount of waste that is subject to recycling is also displaying an upward tendency (increase by more than 11%). The overall volume of waste produced in the same period increased by just under 11%, which means that there has been a slight improvement in the functioning of the waste segregation system, which should, ultimately, lead to a better quality of the environment.

The opinions which concern the access to drinking water and the increase of green areas are not so unambiguous. With regard to the first of these trends, the most pronounced apprehensions are expressed by the persons representing the towns that struggle already with the drinking water availability problem. An increase in the share of green areas in the spatial structure of the town is expected only by a quarter of the respondents, and this may be the effect of a strong pressure from the industrial and transport functions of the settlement, and also of the lack of consideration of green areas in the spatial development plans. This is so in spite of the fact that for a vast majority of respondents the trend has a positive impact on the town. Quite significant apprehensions are caused by the extreme weather phenomena, which, in the opinion of the majority of the respondents, shall intensify and they may have a very negative influence on the inhabitants and on the spatial structure of the town.

Conclusions

Successful small towns are characterised by the advantageous course of socio-economic processes which contribute to a higher quality of life for the residents, while they stimulate the development of the spatial structure, featuring a clearly

over-average dynamics in relation to other urban centres. The adoption of the thus understood definition allowed for the identification of the small towns of success in Poland, using a set of diagnostic variables, expressed through the indicators of both static and dynamic nature.

The study made it possible to answer the research questions. So, the significance of geographical location in relation to large cities turns out to be significant, but many successful cities are also located in the areas of the inner periphery; regional potential also plays a significant role. The success of cities within these areas is due to the proximity of a large city, which determines the flow of people, capital and the development of entrepreneurship. Such a location guarantees not only the development of cities within the agglomeration, but also of rural areas, which are an area of close cooperation with small centres (Bański 2014). In terms of the size structure, the biggest group is constituted by the smallest centres, but this is primarily caused by their high share in the total number of small towns; the relative share of success centres is the highest among the biggest small towns. It is worth mentioning that among the peripherally located success towns quite an important share is constituted by the county seats, this being the consequence of the wide range of economic functions that they fulfil. Considering the morphological distinctions of the success towns (settlement towns, industrial towns, dichotomous towns, respite towns), the biggest group is constituted by the settlement town due to their location in the direct vicinity of the biggest provincial centres.

The answer to the second and third research questions was possible thanks to conducting a survey. The analysis of the opinions on the selected social, economic and environmental trends in the perspective of the year 2040 demonstrates, generally, the optimism of the successful town authorities. The majority of the proposed potential trends, characterised by the advantageous orientation, were confirmed by the respondents, and their influence on the development of town was assessed quite positively. At the same time, the study identified some challenges, which may constitute serious problems for the success towns in the perspective of the year 2040. These include: the ageing of the resident population; the increase of expenditures on social purposes; the migration outflow; the increased demand for energy; and the extreme weather phenomena. A clear majority of the respondents thought that such processes would take place in their town and they exert a negative influence on development.

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Smart urban governance: a collaborative framework for sustainable and inclusive cities

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Abstract: The governance of smart cities is essential for addressing complex urban challenges, while advancing sustainability, and improving the quality of life for citizens. This study explores governance models for smart cities through a hybrid Analytical Hierarchy Process (AHP) – Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) framework, employing expert evaluations to prioritise and rank governance alternatives. The results showed Smart Urban Collaboration as the most effective governance framework, owing to its capacity to foster inclusivity and sustainability. The analysis also underlined the critical role of social inclusion in urban governance, emphasising the importance of involving diverse stakeholders in decision-making processes. Such participatory approaches are crucial for building citizens' trust and collaboratively developing innovative solutions to urban challenges. Sustainability was identified as the next priority, highlighting the need for such urban governance frameworks to tackle environmental issues like climate change and resource scarcity. Smart cities can move towards sustainable development goals by strategically utilizing technology in stakeholders' involvement. This work offers practical recommendations and insights for policymakers, urban planners, and academics aimed at creating urban environments that are resilient, inclusive, and sustainable.

Keywords: smart urban governance; sustainability; social inclusion; participatory urban planning; technological innovation; AHP-TOPSIS

Introduction

The rapid growth of urbanisation and technological advancements have transformed the concept of smart cities (Xu and Wang 2023), which utilise information and communication technologies (ICTs) to enhance the quality of urban life, to improve operational efficiency, and to ensure sustainability. There is, despite its wide diffusion, no official definition of the term "smart city" (Neirotti et al. 2014, Caprotti 2019, Patrão et al. 2020, Tan and Taeihagh 2020, Desouza et al. 2021). Nonetheless, every vision

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concerning the smart city basically underpins its concept to create synergies between social structures and new technologies brought by the influence of ICTs (Dameri and Benevolo 2016). Meijer and Thaens (2018) described smart cities as emergent socio-technological systems aimed at solving urban challenges by harmonising technological and human capabilities.

Technology alone cannot make cities smart. The recent literature emphasised that smart cities should be about the citizens and their stakeholders. Indeed, this focus on citizens and stakeholders concerns the participatory governance in the realm of smart cities (Garcia Alonso and Lippez-De Castro 2016). Smart cities are not only about technological advancement but also about creating frameworks which improve sustainability and the quality of life for all stakeholders in real-time (Meijer and Rodríguez Bolívar 2016, Ahvenniemi et al. 2017). This is because the collaboration between the governments, the citizens, and other stakeholders in wide ways is indispensable to reach the overarching goals of smart cities, namely enhanced quality of life and sustainability (Bătăgan 2011, Dameri and Benevolo 2016, Merino-Saum et al. 2020, Toli and Murtagh 2020).

Governance has emerged as one of the most pressing challenges in smart city development (Rodríguez Bolívar and Meijer 2016). Abdalla et al. (2019) identified governance as a key obstacle for decision-makers, while Noori et al. (2020) argued that governance structures are critical determinants of success. Governance in this context extends beyond government structures to include processes, norms, and collaborative mechanisms that facilitate stakeholder involvement (Johnston and Hansen 2015, Roszkowska and Wachowicz 2024).

This led to the coining of the term "smart governance", describing the form of governance that would work for smart cities (Dameri and Benevolo 2016). Giffinger et al. (2007) count smart governance among the six features that characterise a smart city. Its meaning varies, with some focusing on the use of ICTs and data management (Schuurman et al. 2012), and others on social inclusion, political participation, and administrative efficiency (Caragliu and Del Bo 2012, Nam and Pardo 2014). As collaboration is generally at the heart of smart governance, the European Commission (2025) highlighted that smart cities are not only about using ICT; rather, cities are to be more interactive and responsive in administering themselves. Unlike traditional e-governance, smart governance involves stakeholders more actively in decision-making and it creates an atmosphere of cooperation and mutual accountability (Scholl and Scholl 2014, Viale Pereira et al. 2017, Almadani et al. 2023). The collaborative model has been found in practice in American smart cities, with models of inclusive governance being in place (Hu and Zheng 2021). So, smarter cities have more significant problem-solving capacities in economic, social, and environmental areas but they also demand quite new structural changes in governance.

A critical question, therefore, remains: can smart cities be effectively governed by traditional structures, or must they adopt new governance models that better meet their particular demands? The current study tries to answer this question by assessing and by ranking governance levels for smart cities based on expert opinions. Also, it aims to offer practical guidance for urban governments in the design of governance frameworks that are in tune with the capabilities of smart cities.

Methodology

This research aimed to identify the most suitable governance model for smart cities by applying an integrated multi-criteria decision-making (MCDM) framework. Given the heterogeneous and complex nature of smart governance, we used a hybrid AHP-TOPSIS methodology by combining the strengths of the Analytical Hierarchy Process (AHP) in deriving criteria weights, and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) in evaluating alternatives. The study drew upon experts' contributions in smart city governance, who conducted pairwise comparisons for the criteria and scored the alternatives. This structured approach ensured a comprehensive evaluation of governance styles that aligns with both theoretical frameworks and practical implications.

AHP is a structured decision-making tool that uses pairwise comparisons to derive criteria weights, ensuring alignment with the expert judgments (Saaty 1990, Saaty 1994). Through AHP, we determined the relative importance of five governance criteria (social inclusion, sustainability, information sharing and openness, transparency, creativity and innovation) and developed a hierarchical structure (Figure 1), comprising: a) goal: to determine the most suitable governance level for smart cities; b) criteria: the five governance criteria, as derived from the literature; c) alternatives: four governance models, including: traditional governance; smart decision-making; smart administration; and smart urban collaboration.

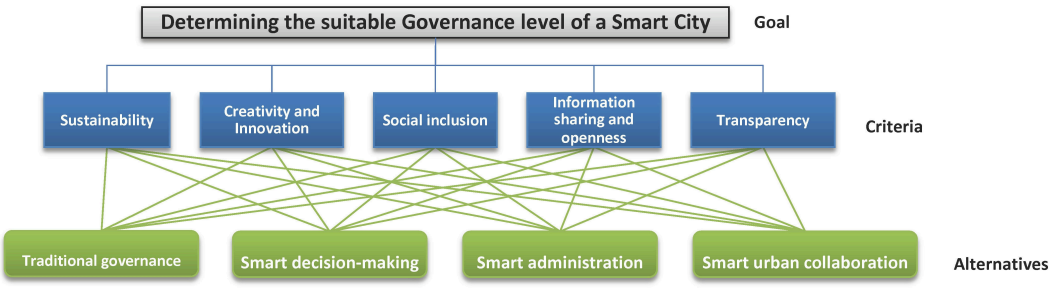

Figure 1. The decision-making tree for levels of smart governance.
(The connections between criteria and alternatives indicate their influence)

The experts conducted pairwise comparisons using the Saaty's 1-to-9 scale. Pairwise comparison matrices were normalised, and criteria weights were derived. Consistency ratios (CR) were calculated to ensure reliable judgments, with all matrices meeting the threshold of CR ≤ 0.1. The resulting criteria weights were used as inputs for the TOPSIS analysis, integrating expert insights into the decision-making framework.

TOPSIS is a well-established method for multi-criteria decision-making that determines closeness to an ideal solution, representing the best possible performance, and an anti-ideal solution, representing the worst option (Lai et al. 1994). TOPSIS was used to rank the governance alternatives by evaluating their proximity to an ideal solution. The process began by constructing a decision matrix that captured the performance of the governance alternatives across the five criteria. We normalised the matrix using vector normalisation and we weighted it with AHP-derived criteria weights. We then identified the ideal and anti-ideal solutions, reflecting each criterion's best and worst values. Finally, we calculated the Euclidean distances of each alternative from these solutions. We then derived the closeness coefficient (CC) in order to measure the relative proximity of each alternative (smart governance level) to the ideal solution.

We applied this hybrid approach to combine the strengths of AHP and TOPSIS. In fact, using AHP, ensured the reliable weighting of criteria and we provided a systematic ranking of alternatives considered for smart governance levels by merging the results of AHP with TOPSIS. By integrating expert insights into a mathematically rigorous framework, the methodology aligned the governance evaluations with the complex requirements of smart cities.

Expert panel and data collection

To ensure a robust evaluation of governance alternatives, we carefully selected a panel of academic experts specialised in smart city governance topics, by using a systematic approach to identify and engage these experts. We conducted a literature review across three academic databases—ScienceDirect, Sage, and MDPI—using the keyword "smart city governance". Based on their contributions to relevant publications, 138 experts were identified and invited to participate in the study via a structured email campaign.

We designed a questionnaire to collect pairwise comparisons for criteria weights (AHP) and performance evaluations of governance alternatives (TOPSIS). The questionnaire was distributed to the 138 identified experts, and 15 responses were received, representing a 11% response rate. After evaluating the responses for consistency using the AHP framework, three responses were excluded due to high inconsistency ratios (CR > 0.1). Consequently, data from twelve experts were included in the final analysis.

The expert panel was diverse in terms of geographical and professional background. They represented various countries, including France, UK, Australia, Italy, Austria, Croatia, Hong Kong, Iran, and Malaysia. Approximately 42% of the respondents

were female and 58% were male. The panel included nine Ph.D. holders (three full professors and two associate professors), two Ph.D. students, and one MSc graduate, further ensuring a high level of expertise.

The collected data were analysed using the AHP-TOPSIS framework. Experts provided pairwise comparisons of the five governance criteria and subsequently scored the four alternatives against each criterion. This dual-input approach facilitated the evaluations that captured both the relative importance of criteria and the specific performance of governance alternatives. The application of AHP to derive criteria weights, and TOPSIS use to rank alternatives ensured that expert judgments were consistently and rigorously applied throughout the analysis.

Governance alternatives and criteria

We evaluated governance styles through a set of alternatives and criteria that reflected the varying levels of transformation in urban governance and critical dimensions of effective smart city management. These elements, derived from an extensive literature review, provided a robust foundation for assessing the governance levels.

Governance alternatives

The governance alternatives reflected the varying organisational and structural transformation levels in smart cities (Osborne 2006, Torfing et al. 2012, Meijer and Rodríguez Bolívar 2016). Guided by the work of Rodríguez Bolívar and Meijer (2016), we selected the alternatives that showed progressive shifts in governance practices, from conventional models towards collaborative frameworks involving multiple stakeholders. These alternatives were conceptualised as follows:

Traditional Governance represents the status quo with little to no change within governmental processes. Traditional governance relies extremely on established hierarchies and it remains unlinked or partially integrated into advanced technologies and stakeholder networks (Alkandari et al. 2012). Although satisfactory for specific contexts, this model most often fails in modern cities for dynamic requirements (Roszkowska and Wachowicz 2024). While efficient for some contexts, this approach often struggles to meet the dynamic requirements of modern cities (Rodríguez Bolívar and Meijer 2016, Roszkowska and Wachowicz 2024).

Smart Decision-Making: it is not about the restructuring of the organisation or governmental institutions, but it emphasises the need for the restructuring of the decision-making process (UNESCAP 2009, Schuurman et al. 2012, Walravens 2012). It supports evidence-based policymaking, and it promotes decision efficiency with no alteration in governance structures per se (UNESCAP 2009, Shafik 2025).

Smart Administration implies the arrangement of the internal structure of the government. In other words, the existing designs of the government use innovative

administrations to aptly deal with the requirements of smart cities (Batty et al. 2012, Caragliu and Del Bo 2012, Gil-Garcia et al. 2016, Viale Pereira et al. 2017). Also, smart administration enables adaptability and the optimisation of resources within the already established organisational framework (Bui et al. 2025).

Smart Urban Collaboration represents a higher level of governance by merging an internal and external restructuring process toward the creation of collaborative networks. This strategy underlines the shared responsibility of governmental institutions, other stakeholders, and citizens for an interactive form of governance through collaborative policymaking (Noori et al. 2024).

By contrast, smart administration and smart urban collaboration can be viewed as internal and external collaboration, respectively (Rodríguez Bolívar and Meijer 2016). Internal collaboration refers to city departments working with each other and working with other public organisations, such as county and regional governments as well. External collaboration means that all these governmental agencies work with companies, various civic groups, and associations, as well as with the citizens themselves (Viale Pereira et al. 2017). In smart cities, ICT can enable both internal collaboration (Ae Chun et al. 2012), and external collaboration (Viale Pereira et al. 2017). Smart and collaborative governance represents the means for the urban government to arrive at better information and service availability (Angelopoulos et al. 2010), and to experience enhanced agency information sharing, resource use, and more active policymaking (Rodríguez Bolívar and Meijer 2016).

Evaluation criteria

The relevant literature on governing smart cities provided the basis for selecting the criteria that are critical to effective governance in smart cities. In this analysis, the governance alternatives were evaluated against five criteria. While some of them, like creativity and innovation, can be recognised explicitly in the realm of smart governance, others are considered in a broader area and they are characterised as criteria for good government:

Sustainability: there is no settled definition of sustainability (Bibri and Krogstie 2017, Bibri 2018). Its prominence emerged in the 1980s, when the awareness of development's environmental and social impacts increased, culminating in frameworks like the United Nations Sustainable Development Goals (SDGs). Notably, SDG 11 emphasises the creation of inclusive, safe, resilient, and sustainable cities (United Nations 2025). These challenges are higher in urban areas because they consume over 70% of the world's resources and they contribute approximately 72% towards greenhouse gas emissions (Patrão et al. 2020). As urbanisation increases, the consideration of cities should go towards governance structures that will engrain sustainability into planning and decision-making.

Smart cities have recently garnered ample attention, and their potential power to respond to this challenge is ICT (Neirotti et al. 2014, Bibri and Krogstie 2017, Bibri 2018). ICTs not only improve real-time monitoring, but they also allow participatory governance frameworks that are combined with the sustainability goals of the city, as noted by Xu et al. (2024). Smart cities leverage these technologies to address environmental challenges, such as climate change and resource depletion, while fostering collaboration among the stakeholders (Serdaoui and Cherkaoui 2023, De Filippi and Carbone 2025). Furthermore, it is increasingly recognised that sustainability underpins urban smartness, and researchers emphasise its inclusion in all spheres of governance (Yigitcanlar et al. 2019, Mavri et al. 2024).

Creativity and innovation: they are some of the major drivers of smart city development. This enables cities to apply new ideas and technologies in solving complex challenges. Innovation is closely tied to a city's "smartness", as it promotes transformative approaches in domains such as smart transportation, renewable energy, and mobility (Meijer and Thaens 2018, Noori et al. 2020).

Empirical studies indicate that innovation is the bedrock of smart governance. For instance, Rodríguez Bolívar and Meijer (2016) and Anthopoulos et al. (2015) established that innovation begets socio-technological processes, equipping cities with a prudent ability to adapt and to thrive, so labs and innovation centres have value for the community. As indicated by Noori et al. (2020), "nurturing of the innovation environment" has strong technical links to application domains such as smart transportation infrastructure, renewable energies, and smart mobility.

Furthermore, innovative environments support bottom-up participation and decision-making, i.e., 'two-way communication,' 'co-creation,' and 'co-designing' (Giffinger and Lu 2015, Noori et al. 2020). In this process, the role of ICT is prominent and recent evidence showed that innovative environments favour not only technological development but also participatory decision-making and inclusive governance (Kourtit et al. 2012, Wang et al. 2024). This innovation embedded in the governance frameworks helps a smart city to develop adaptive systems for addressing evolving urban demands with long-term sustainability and growth (Xu et al. 2024).

Social inclusion: it is integral to smart governance, requiring the active participation of the citizens, of private sector actors, and institutions in urban development (Giffinger and Lu 2015). Technology is a tool for effective collaborations in order to foster trust, accountability, and equitable governance (Harvey 2012, Wang et al. 2024), so smart cities can enhance public value and inclusivity by shifting decision-making power to broader stakeholders.

Participation is defined through the direct involvement of the community in decision-making processes (Harrison et al. 2012). This engagement not only serves to create trust in public institutions but also to enhance equitable management mechanisms of urban areas (Rodríguez Bolívar 2017). Recent literature points out the necessity of

participatory platforms to enable various groups to make smart city benefits spread equitably and congruent with the goals of sustainability (Xu and Wang 2023).

Information sharing and openness: it is essential for effective urban governance, particularly in smart cities where transparency and data-sharing empower stakeholder participation (Johnston and Hansen 2015). ICT and open government data (OGD) facilitate real-time information sharing for smart governance (Viale Pereira et al. 2017, Lodato et al. 2021). Emerging studies highlighted how accessible data systems catalyse inclusivity and participation, particularly in fostering trust and equitable governance (Bressane et al. 2024).

By removing the barriers in the flow of information, ICT basically allows the governments to take up adaptive and decentralised systems which address various challenges, including climate change, resource management, and promoting sustainability goals (Ae Chun et al. 2012, Mehmood et al. 2024). Transparent data practices with participatory platforms could make smart city governance resilient and inclusive (Farag Bedewy 2024).

Transparency: it is defined as the openness of government operations and the access to information by stakeholders (Harrison et al. 2012), and it improves citizen engagement, and it reduces corruption. In this respect, it thereby makes it easier for their contributions toward governance processes to be informed, with the view of aligning public trust to policy objectives. Recent developments in digital tools, such as blockchain and open government data initiatives, have extended the scope of transparency by providing new mechanisms for real-time monitoring and participatory decision-making (Zarrabi et al. 2024). These tools create a space for stronger public-private collaborations.

Recent studies have found that transparency is not only imperative, but it is also key to solving issues related to public mistrust and inefficiencies in governance, as identified by Bukhari et al. (2024). For example, different transparency-related initiatives have shown the potential to contribute to the sustainability of smart cities in manifold ways and by embedding environmental monitoring into data-sharing platforms for better purposes of urban planning. Ajaj et al. (2024) went further with this aspect, indicating that the effects of transparency, which guarantees a rise in social inclusiveness due to the very nature of access that governance processes guarantee to large and diverse demographic groups, assure the creation of equal opportunities to engage with initiatives relevant for the context of their urban setting. As smart cities adopt increasingly complex digital ecosystems, embedding transparency in governance frameworks ensures adaptive capacity, accountability, and alignment with broader sustainability objectives (Nanayakkara et al. 2024).

By integrating these governance alternatives and evaluation criteria, we developed a comprehensive framework which aligns theoretical insights with practical governance needs, ensuring relevance to both academic and policy contexts.

Results

We used AHP to compute the weights for the selected criteria, incorporating expert pairwise comparisons. The consistency ratio (CR) of 0.02 confirmed the reliability of the evaluations (CR≤0.1). The results showed that social inclusion is the most important criterion (weight=0.327), followed by sustainability (0.203), and by information sharing and openness (0.195). Lower-ranked criteria included transparency (0.148), and creativity and innovation (0.127). These weights indicated priorities shifting toward collaborative and participatory governance in smart cities, where inclusivity and environmental sustainability are paramount.

The findings from the experts' views aligned with Caragliu et al. (2012), and Garcia Alonso and Lippez-De Castro (2016). This order of the importance of criteria clearly indicates that academic experts evaluate the performance of smart cities based on public participation, as well as environmental considerations (sustainability). Less attention was paid to creativity and innovation. Summing up the views of the selected academic experts we noticed that public participation and sustainability received higher importance than the tools.

Applying the hybrid AHP-TOPSIS methodology enhanced ranking robustness. The AHP-derived weights informed TOPSIS, allowing us to rank governance alternatives by their proximity to the ideal and anti-ideal solutions. This approach considered both the best-case and worst-case scenarios, ensuring a balanced evaluation.

For the relative closeness scores of each governance model (Table 1, Figure 2), Smart Urban Collaboration emerged as the most suitable governance model with a relative closeness score of 1.0. This alternative demonstrated its superiority in addressing critical criteria, particularly social inclusion and sustainability (Figure 3). Smart Administration ranked second with a relative closeness score of 0.724, reflecting its ability to restructure internal governmental operations effectively. Smart Decision-Making placed third (0.523), highlighting its focus on enhancing decision processes without extensive structural changes. Traditional governance was the least preferred alternative, with a score of 0.0, confirming its inadequacy in meeting the complex demands of modern smart cities.

Table 1. Preference of smart governance levels based on the viewpoints of academic experts

Governance Level	Distance to Ideal	Distance to Anti-Ideal	Relative Closeness (RC)	Rank
Smart urban collaboration	0.000	0.218	1.000	1
Smart administration	0.160	0.160	0.724	2
Smart decision-making	0.105	0.115	0.523	3
Traditional governance of a smart city	0.218	0.000	0.000	4

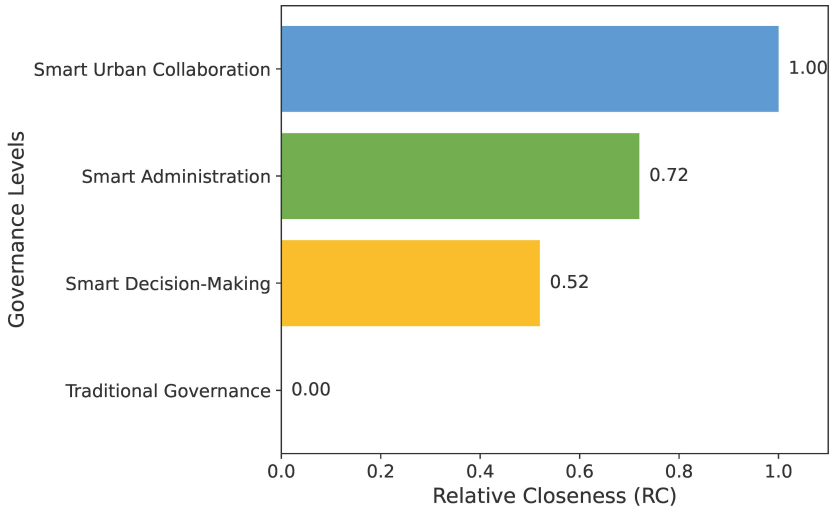

Figure 2. Relative closeness of the levels of smart governance alternatives

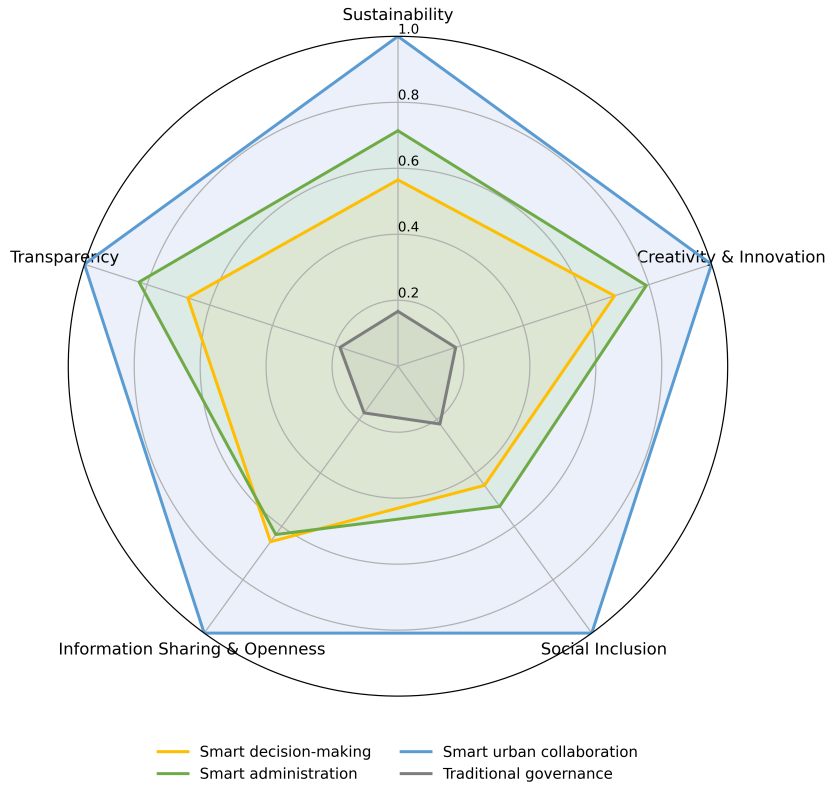

Figure 3. Performance of governance alternatives across criteria

Discussion

Governance structures are decisive in whether smart cities are targeted to address issues of sustainability, inclusivity, and adaptability, so the core challenges of our time fall in line with the core principles of sustainable development. Through a hybrid AHP-TOPSIS methodology, this work has analysed a few governance frameworks, and it found that Smart Urban Collaboration is the best one. It points, in fact, to the importance of collaborative, participatory governance in engaging with the complexities of the urban environment, which aligns with the global call for sustainable cities through the SDG 11 (Rodríguez Bolívar and Meijer 2016, Ahvenniemi et al. 2017).

The dominance of social inclusion as the highest-weighted criterion reflects an emerging priority for equity and participatory governance in smart cities. Governance systems that actively involve citizens in decision-making foster transparency, trust, and co-creation, which are critical for the sustainable urban transformation (Garcia Alonso and Lippez-De Castro 2016). This approach, for example, is what Smart Urban Collaboration does: it enables various stakeholders to participate in urban planning and decision-making. It is an inclusive model that makes sure that governance frameworks respond particularly to the needs of deprived classes at the societal level toward improved social cohesion and sustainability.

Sustainability is the second key criterion in terms of urgency, as governance models must urgently tackle a number of pressing environmental stresses, including climate change, resource depletion, and pollution. It places increasing demands on urban governments to integrate sustainability into their decision-making. Smart Urban Collaboration can provide the pathway toward leveraging ICTs and partnerships to implement adaptive, effective, and sustainable policies (Bui et al. 2025).

Real-world examples are abundant and they demonstrate the significant consequences of ignoring environmental challenges. For instance, the lack of sustainable urban planning and governance frameworks has resulted in severe water shortages and air pollution crises in a number of major metropolitan areas in Iran (Shamsipour et al. 2024). As other examples, the ongoing urban sprawl and environmental degradation being witnessed in cities such as Jakarta, Indonesia, and Metro Manila, Philippines, are typical risks of not addressing sustainability in governance (Karimi and Sultana 2024). These examples underpin the urgent need for urban policies that put environmental resilience at the forefront, with the accent on sustainability, not as a desirable feature, but as an indispensable one for the survival and prosperity of modern cities.

The findings of this research highlight the importance of inclusiveness and sustainability in the context of smart urban governance, indicating a paradigmatic change in the working mechanisms of governance structures. The interrelationship of assessment criteria and governance outcomes identifies a systemic pattern, whereby inclusive, transparent, and participatory approaches lead to more resilient and sus-

tainable urban futures. This conceptual alignment between governance structures and sustainable development underpins the policy relevance of our results and it echoes the broader objectives of SDG 11 (Figure 4).

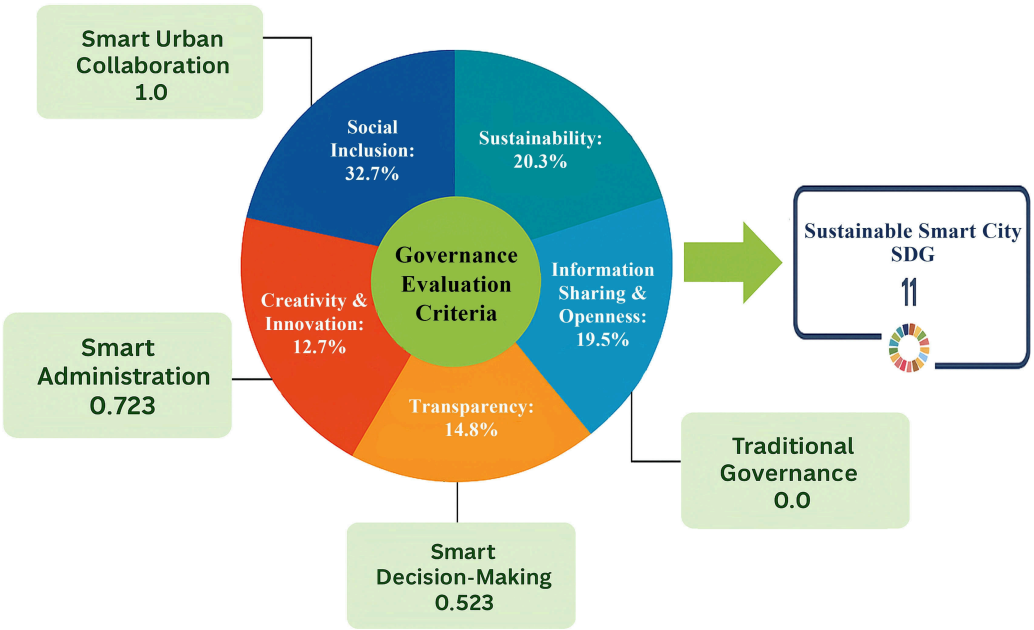

Figure 4. Conceptual scheme linking governance evaluation criteria, governance alternatives, and sustainable urban development

While Smart Administration and Smart Decision-Making models enhance governance processes and they improve decision-making internally to governments, their unavailability to widespread collaboration limits their applicability in dynamic urban environments. Traditional governance's low ranking also signifies that it is ill-equipped to address the interlinked demands of the modern smart city. Rigid and hierarchical governance systems are poorly suited for achieving the adaptability, inclusiveness, and sustainability that urban resilience requires (Roszkowska and Wachowicz 2024).

Governance frameworks should focus on partnerships among governments, citizens, and private actors. The results confirm that it is time for policymakers and urban planners to turn their attention to transparent governance mechanisms, which would allow public trust and accountability with more informed participatory decision-making. Sustainability indicators within governance practices ensure that policies are aligned with environmental and social priorities. These emerging technologies, ranging from AI to blockchain, offer opportunities to better enhance the efficiency and adaptability of governance in supporting cities toward sustainable futures.

Despite the strength in the AHP-TOPSIS approach, a significant methodological weakness was the relatively narrow group of expert respondents involved in the research. While expert selection criteria and response consistency ensured rigor, the small sample size may affect the generalisability of the findings. Future research should include extended views, including practitioners and policymakers, to enrich the analysis and to validate the framework across various urban contexts.

Conclusions

This research examined the importance of inclusive, sustainable, and collaborative governance models in shaping the future of smart cities. Applying a hybrid AHP-TOPSIS methodology, we identified smart urban collaboration as the most effective governance framework. This specific framework stood out in its ability to manage an inclusive and sustainable model, having actively engaged its stakeholders in decision-making. The prominence of social inclusion and sustainability as key criteria reflected the growing recognition for governance systems to address equity issues and the environment in urban management.

These findings stress gaps in conventional frameworks of governance, which are often too rigid, unsustainable, and non-inclusive to accommodate the challenges of smart urban systems. In other words, the governance frameworks should be flexible enough to easily enable close collaboration among governments, citizens, and other stakeholders. Moreover, policymakers should prioritize participatory platforms, which would ensure the empowerment of citizens while upholding the requirements for transparency and equity in governance and sustainability. Advanced technologies like artificial intelligence and IoT provide prospects to develop more effective and flexible governance structures capable of achieving sustainable urban development goals.

While prioritizing academic expert opinions is indeed insightful, it tends to overlook the practical challenges that policymakers and practitioners face regarding legal and resource constraints. Future research should include these perspectives to make governance recommendations actionable and context-sensitive. There is also a need to explore models of governance that are region-specific and that would serve the specific socio-economic and cultural dynamics better. When developed, such areas have the potential for further enhancement in establishing appropriate governance systems that are theoretically sound and practically viable.

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The Relationship between Economic and Institutional Resilience Based on a Staged Critical Review of Literature

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Abstract: The present study aims to investigate the relationship between institutional resilience and economic resilience by proposing a theoretical model on this and by addressing questions about the key institutional variables and actors that are important for economic resilience. To achieve this, a staged literature review method was employed. For analysing the literature, there were two approaches: the research agenda-based approach, which involved categorising the necessary variables and the important actors in institutional and economic resilience; the second approach involved critically reviewing and continuously comparing the results of the conceptual model related to the relationships between the variables. The research findings showed that the important variables related to institutional and economic resilience fall into three categories: economic institutions (responsible for facilitating and monitoring economic interactions); governance (responsible for policymaking, implementation, and resource management); and legal frameworks (they provide supportive and legal platforms for the better functioning of managerial and economic institutions). The conceptual framework identified three dimensions – intra-systemic, extra-systemic, and meta-systemic – which focus on the internal institutional elements, communication and coordination with the higher levels of governance, or they facilitate interaction. The framework enhances the understanding and analysis of institutional and economic resilience in cities.

Keywords: economic resilience; institutional resilience; urban development; intra-/extra-/meta-systemic institutions

Introduction

Urban resilience is crucial for ensuring that cities can withstand and recover from various shocks and stresses, including natural disasters and human-induced changes. By building urban resilience, cities can ensure their long-term sustainability and well-being (Weilant et al. 2019). Urban resilience is determined by three fundamental elements: resistance, recovery, and adaptation (Chen et al. 2020, Amirzadeh et al. 2022), which define a city's ability to withstand and resist to the impact of shocks and stresses,

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to recover and to improve quickly after a shock occurs, and to adapt to changes and to create positive transformations in its structures and functions.

Urban resilience can be categorised into short-term and long-term resilience (Sanchez et al. 2018, Suárez et al. 2020). The former relates to a city's prompt response to unforeseen shocks and to stresses like natural disasters, to terrorist attacks, and health crises, while the latter pertains to a city's capability to anticipate and to manage long-term changes and challenges, such as climate change, demographic shifts, economic and technological developments. Improving urban resilience requires a holistic approach that involves various stakeholders, including policymakers, urban planners, community organisations, and the residents (Zhang et al. 2020). By investing in infrastructure, by building social networks, and by promoting sustainable development, cities can enhance their resilience, further ensuring the well-being of their residents.

In urban contexts, economic resilience and institutional resilience are encompassed within the urban resilience (Rose 2007, Masnavi et al. 2019, Bedinger et al. 2020). Economic resilience refers to a city's capacity to withstand and to rebound from shocks and stresses, necessitating a diverse urban economy with varied industries, occupations, and services that safeguard against economic fluctuations and that facilitate adaptation to evolving conditions (Martin and Sunley 2017, Zeng et al. 2022). To prepare for economic growth and changes, cities must cultivate innovation and nurture their startups and entrepreneurs by establishing research and development centres, by providing financial support, and by offering consultancy services, thereby creating new opportunities (Brown and Mason 2017). Another pillar of economic resilience in cities is the investment in physical and human capital, strengthening investments in education and vocational training, improving the working conditions, and creating job opportunities, which can contribute to economic growth and to protect the city against economic changes (Cheng and Zhang 2020, Hernita et al. 2021). Key economic sectors, such as small and medium-sized enterprises, tourism, and local production can significantly contribute to economic resilience in cities by demonstrating quick responsiveness, being organised, and taking advantage of new opportunities during crises and economic changes (Skouloudis et al. 2020).

Institutional resilience refers to the ability of city institutions, such as the government, non-profit and social organisations, to respond to and to improve from shocks and stresses (Cimellaro et al. 2016, Ro and Garfin 2023). It seems that strong and effective governance structures and leadership (Aldianto et al. 2021), transparent decision-making processes (Burnard et al. 2018, Rossignoli et al. 2018), coordination between different institutions (Huck et al. 2020, Miceli et al. 2021), and the ability to mobilise resources (Barasa et al. 2018, Rahi 2019) and to implement strategies for institutional resilience are essential. Additionally, cities should plan for identifying and for assessing potential risks and vulnerabilities in all areas through comprehensive and preventive processes (Coaffee et al. 2018), by developing plans to respond to stresses (Figueiredo et

al. 2018), by conducting risk assessments (Battiston and Martinez-Jaramillo 2018), and by implementing measures to reduce and to adapt to various hazards. Building strong relationships and collaboration between different institutions (Sheikhi et al. 2021), including government organisations, community-based organisations, businesses, and universities, is crucial for institutional resilience because it enables resource sharing, expertise and knowledge sharing (Abualoush et al. 2018), as well as coordinated efforts in response and recovery from hazards (Kim and Kreps 2020).

Institutional and economic resilience are two critical components of urban resilience, as they can help cities to prepare for and to respond to these shocks and stresses. An appropriate institutional framework is essential for economic resilience, as it can create an environment that promotes economic growth, innovation, and investment while also ensuring that regulations and laws are in place to protect against risks and threats. The relationship between the different dimensions of economic and institutional resilience is complex, as these two components are interdependent and they can influence each other. A comprehensive analytical model can be developed to illustrate the relationship between institutional and economic resilience, which can help policymakers and urban planners to develop strategies to enhance urban resilience and to promote sustainable development.

Strong institutions and a diverse economy are interplayed, with effective institutions contributing to economic growth (Bosma et al. 2018, Davidson et al. 2018) and a strong economy providing resources to support institutions (Raven et al. 2019), but conflicting policies and institutions can undermine both institutional and economic resilience. For example, policies that encourage investment to promote economic growth may create an environment for corruption and law violations that ultimately weaken institutional resilience. Cities must strike a balance between laws and regulations that suit their economic needs and conditions, as overly rigid and bureaucratic institutions can impede economic innovation and flexibility (Scheba and Turok 2020). This way, while maintaining institutional standards and creating a suitable environment for innovation and creativity, there is also enough flexibility in the face of economic growth and development. The presence of strong and effective institutions, such as the judicial system, legal system, financial system, and other related institutions, can help promote transparency, fight corruption, and develop institutional infrastructure for the economy (Arslan and Alqatan 2020). Institutionalisation involves establishing an enabling environment for the economic actors, achieved by addressing external challenges, by promoting transparency, by creating infrastructure for innovation, and by providing education and training opportunities.

In order to balance institutional and economic resilience, it is necessary for different sectors and agencies to collaborate and to coordinate at different levels, and for platforms to be provided for the exchange of information and experiences between the different sectors. Therefore, identifying actors, determining the role of

each of them, determining their position in economic and institutional resilience, and mapping their relationships with each other to achieve a conceptual synergy of actors' interactions in the field of resilience is important. Institutional actors, such as laws, policies, and systems, play a crucial role in enhancing economic performance and resilience, by creating effective regulations, by promoting institutional and economic resilience, and by strengthening the existing institutions (Ranta et al. 2018). Economic agencies, such as businesses, investors, entrepreneurs, and individuals, play a crucial role too in enhancing the economic resilience of cities (Surya et al. 2021), by generating employment (Steiner and Atterton 2015), by increasing production and income (Makate et al. 2019), by improving quality of life (Jong et al. 2015), and by creating new economic opportunities. Coordination and cooperation between institutional and economic actors are crucial, with institutional actors developing policies to strengthen economic actors, while economic actors comply with the laws to enhance institutional resilience (Amin 1999).

Based on the perspective of a city as a complex system (Maranghi et al. 2020), the present research focuses on the relationship between institutional and economic resilience in cities as two determining factors for urban resilience. The research approach creates a link between the different elements of the economic and urban management institutions, rather than focusing on the distinct components and criteria of institutional and economic resilience. Therefore, the research objectives can be categorised into two important exploratory and analytical goals. To achieve the exploratory goal, a comprehensive review of theoretical and empirical literature was conducted to identify common criteria and indicators that can create a link between economic and managerial institutions in cities, which were categorised into components and concepts. To achieve the analytical goal, a complete analysis of the relationship between these institutions and the processes that facilitate this relationship was provided in the form of a comprehensive analytical model. To achieve the research objectives, the present study must provide appropriate answers to the following research questions:

1. Is there an appropriate institutional framework essential for economic resilience?
2. Who are the institutional actors that play an effective role in economic resilience, and what role does each of them have in this resilience?
3. What is the model that can be drawn for the relationship between institutional and economic resilience?

Methodology

Since the current research aims to conduct a comprehensive and explanatory analysis of the theoretical and empirical literature, a systematic literature review method has been deemed appropriate (Nuzzo et al. 2019, Snyder 2019). This method involves four distinct phases: (1) the review design; (2) conducting the review; (3) performing the

analysis; and (4) writing the review report. For this literature review, a staged review design (Torraco 2016) was adopted, which entailed an initial broad review of sources followed by a more detailed examination.

A comprehensive selection of sources, including articles, books, and reports, was conducted without restrictions in order to ensure a diverse and inclusive review and analysis for this research (Hiebl 2023). The choice to include various types of sources was deliberate, as it allowed for a holistic exploration of the research topic from different perspectives and disciplinary backgrounds (Raymond et al. 2010). The peer-reviewed articles provided up-to-date research findings, empirical evidence, and rigorous methodologies; the books offered in-depth theoretical discussions; and the reports presented practical applications and insights from policy or industry contexts. By including a variety of sources, the research aimed to capture the breadth and depth of knowledge available on the topic (Petersmann 2008). This comprehensive approach ensured that no valuable insights or relevant findings were overlooked, enabling a thorough examination of the existing literature and a robust analysis of the research topic. The integration of diverse sources further allowed for the identification of gaps and inconsistencies in the literature, thereby contributing to a more cohesive understanding of the research topic.

To begin, a general review was conducted using various symbols, such as '*and*' or'+', in combination with keywords related to economic resilience, institutional resilience, and urban resilience. This approach aimed to identify sources which, simultaneously or in relation to each other, discuss these concepts within a research or scientific document. The review process went beyond merely reading the abstracts, instead searching for relevant keywords within the full text of the articles. By employing this method, relevant cases that aligned with the research objectives were identified, allowing for a more comprehensive analysis of the topic. Given the large number of articles resulting from this initial search, a decision was made to exclude the older literature. To accomplish this, a time filter was applied during the keyword search (Hiebl 2023), limiting the scope of the literature to sources published from the beginning of the 21st century, specifically after the year 2000. This temporal restriction ensured that the review encompassed the most recent and relevant literature on the subject matter. Despite the fact that the selected resources were in English, it is important to acknowledge that the research was conducted using resources from diverse geographical, cultural, and political contexts. This diversity enhanced the potential for generalisability and the acquisition of comprehensive knowledge. However, it is worth noting that utilising resources in different languages from around the world could further enhance the validity and credibility of the research findings.

In the second step, a detailed examination of 15 articles obtained from the initial review was conducted. These articles were selected based on their close connection to the research topic. Through this analysis, it became evident that the relationship

between institutional resilience and economic resilience can be found in the literature related to concepts such as: institutional environment; institutional approaches; institutional economics; governance; economic growth; policy making; economic development; economic sustainability; economic recovery; and economic vulnerability. These keywords were identified and combined with the keywords of economic resilience and institutional resilience in the third step, in order to establish the main and the subcodes. During the selection process of literature, a screening was conducted to ensure that all the used documents could express the existing realities in the research problem to varying degrees. As a result, none of the identified articles were excluded from the research process. A total of 83 articles were used for coding and criterion extraction, while additional articles were also utilised to provide a better understanding of the relationship between the variables identified from the literature review.

Google Scholar served as the primary database for sourcing the relevant literature due to its extensive coverage of reputable databases. When sources were not fully accessible in this database, the original database was used to download the source material. This approach ensured a comprehensive and diverse range of literature sources for the analysis. In this research, two approaches were employed for the analysis of texts: the research agenda approach; and the alternative model or conceptual framework approach. These approaches involved classifying the selected literature based on conceptual meanings and their explicit or implicit indications in relation to the research statement (Torraco 2016, Elsbach and Knippenberg 2020). By utilising these approaches, a deeper understanding of the research topic was achieved, allowing for the development of a comprehensive and explanatory analysis of the literature.

This classification process was conducted using a critical and constant comparative approach (Hart et al. 2014), where researchers continuously refined the categorisations as they discovered new perspectives and insights within the literature (Watson and Webster 2020). The iterative nature of this process allowed for the identification of emerging themes and patterns, ensuring a comprehensive understanding of the relationship between economic resilience and institutional resilience. To ensure the validity of the categorisations, two experts in the field of economic resilience were involved in the review process. Their expertise and insights helped to refine the codes, criteria, and final components of the analysis (Hart et al. 2014, Ouyang 2014, Hosseini et al. 2016). This collaborative approach enhanced the credibility and robustness of the findings. However, the research process did not conclude with the exploratory findings and categorisation of concepts. The ultimate goal of this study was to develop a new theoretical understanding of the relationship between economic resilience and institutional resilience. To achieve this, a systemic perspective on resilience was adopted, and a model illustrating the interplay between the different components of institutional and economic resilience was developed. This model is presented in the conclusion section of the research, where researchers integrated new ideas with the

existing knowledge and they presented a creative perspective (Torraco 2016, Samnani et al. 2017). This critical approach goes beyond summarising the previous literature and it contributes to advancing the theoretical understanding of the topic. By employing these rigorous research methods and synthesising the new knowledge, this study aims to provide valuable insights into the relationship between institutional resilience and economic resilience, contributing to the existing body of literature in the field.

Results

Legal and regulatory framework

A well-defined legal and regulatory framework that includes protected property rights and the rule of law is crucial for economic resilience (Table 1). These elements provide confidence to investors, foster a stable business environment, and ensure fair dispute resolution. They contribute to increased economic activity and promote long-term growth and resilience.

Well-defined property rights

A well defined legal and regulatory framework with clear and strong property rights is crucial for promoting economic resilience, comprising the strength and clarity of property laws, the independence and efficiency of the judicial ystem, and the level of corruption in the political system. To promote well-defined physical property rights, effective property laws, judicial systems, land registries, and to contract enforcement mechanisms are essential. These actors must work together to provide clear and enforceable physical property laws that protect various forms of tangible property, including land titles and other physical goods. Similarly, effective intellectual property rights protection is necessary to promote innovation and creativity. This protection includes patents, copyrights, and trademarks, which must be clearly defined and enforced by the legal and regulatory framework. Actors such as intellectual property lawyers, patent offices, and other regulatory agencies must work together to ensure that intellectual property rights are protected. Indicators of effective property rights protection include the clarity and strength of property laws, the speed and fairness of court proceedings, the impartiality of judges, and the ease of land and property registration, the effectiveness of dispute resolution mechanisms, and the level of corruption in the political system.

Rule of law

The effect of rule of law in promoting economic resilience cannot be overstated. A solid foundation of rule of law, comprising the absence of corruption, open government,

fundamental rights, and order and security, is critical for creating an environment that is conducive to sustainable economic growth and development. When there is rule of law, businesses operate with confidence, investors make informed decisions, and citizens trust that their rights and interests are protected. The absence of corruption ensures a level playing field for businesses, it minimises rent-seeking behaviour, and it fosters trust in public institutions. Open government, which includes public access to information, civic participation, and judicial transparency, promotes accountability, responsibility, and transparency in government. Fundamental rights, such as civil and political rights and social and economic rights, provide a framework for protecting the interests of the citizens, promoting social cohesion, and ensuring that everyone has equal opportunities to participate in the economy. Finally, order and security, which includes the enforcement of contracts and the effectiveness of law enforcement and the judicial system, provide a stable and predictable environment for businesses and investors, and they promote a sense of security and trust in the society. All of these factors work together to promote economic resilience by creating an environment that is stable, predictable, and it fosters trust and confidence in the economy.

Institutional economics

Institutional economics, through its facilitating and monitoring components, affects the economic resilience of cities. Facilitating institutions create an enabling environment for economic activities, while monitoring institutions ensures compliance and fairness. By fostering a favourable business environment and by promoting transparency, accountability, and the rule of law, institutional economics contributes to the long-term stability and resilience of cities' economies.

Facilitating the exchange of goods and services is a crucial aspect of institutional economics that impacts economic resilience. It involves creating an environment that promotes smooth market transactions. Indicators like ease of doing business and actors, such as business registration agencies, competition authorities, and consumer protection agencies play a role in facilitating these exchanges. Transparency, fairness, and investor protection by securities regulators, efficient tax administration, and unemployment insurance also contribute to economic resilience. Facilitating the exchange of goods and services is vital for creating a favourable environment that supports market transactions and it promotes economic resilience.

Adherence to regulatory standards and guidelines in areas such as product safety, environmental protection, and labour practices is crucial for economic resilience. Indicators measure compliance with these regulations, ensuring consumer protection, environmental sustainability, and fair labour practices. Actors, such as product safety regulators, environmental protection agencies, labour regulators, occupational safety and health agencies, and CSR agencies, enforce these standards. By promoting

responsible and sustainable business practices, adherence to regulatory standards contributes to the long-term resilience and sustainability of the economy.

Promoting competition in markets is crucial for economic resilience. It involves creating a fair and competitive environment, measured by indicators such as market concentration, entry barriers, innovation, consumer surplus, and price elasticity of demand. Various actors, including regulatory agencies and consumer protection groups, play a role in promoting competition. Competition encourages innovation, it enhances consumer welfare, and it prevents market distortions. By fostering a competitive market environment, this sub-category of facilitation contributes to economic resilience, by promoting innovation, consumer welfare, and market efficiency.

Protecting consumers from fraud and abuse is also important for economic resilience, and institutional economics helps to create an environment that supports consumer protection. Institutions such as consumer protection agencies and regulatory bodies help to ensure that consumer products are safe and effective, and that consumers are protected from fraud and abuse. Finally, monitoring and regulating the activities of financial institutions is critical for economic resilience, and institutional economics helps to create an environment that supports financial stability. Institutions such as central banks and regulatory bodies help to ensure that financial institutions are well-capitalised, well-regulated, and able to weather economic shocks.

Monitoring the indicators and actors that influence the regulatory environment is a crucial component of institutional economics. It involves tracking and analysing factors such as tax incentives, deregulation, and trade agreements to assess their impact on economic resilience. Additionally, monitoring the actions of agencies specialised in fiscal policy, economic development, regulation, research and evaluation helps understand their influence on the regulatory environment. By analysing these indicators and actors, policymakers and economists can identify areas for improvement, and enable a more favourable environment for economic growth and resilience.

Protecting consumers from fraud and abuse is crucial for economic resilience. Monitoring indicators, such as consumer education, investigation and prosecution of fraud, regulation enforcement, provision of resources and support, and the collaboration among various actors help to ensure effective consumer protection. By tracking these indicators and actors, policymakers and economists can assess the effectiveness of consumer protection efforts, and they can identify areas for improvement. Effective consumer protection promotes trust in the market, fair competition, and it reduces financial losses for the consumers, ultimately contributing to economic resilience.

Ensuring consumer product safety is vital for the institutional economy and the economic resilience of cities. Indicators like risk assessment, safety standards, testing, recall systems, and complaint reporting contribute to this. Regulatory agencies, such as Consumer Product Safety Commissions, and organisations, like Institutes of Standards and Technology, are involved. Safety and effectiveness of products enhance

consumer confidence, they attract investments, they promote health and well-being, and they ensure legal compliance. Overall, product safety has a significant impact on the economic resilience of cities.

Governance

Governance, including governmental features and policies is crucial for economic resilience. A stable, transparent, and accountable government fosters trust and confidence. Sound policies in fiscal management, monetary policy, trade, and investment promote stability and growth. Strong institutions ensure fairness and enforceability of laws, while a well-designed regulatory environment supports competition, innovation, and consumer protection. Policymakers can enhance economic resilience by improving governmental features, by developing sound policies, by strengthening the institutional framework, and by creating a favourable regulatory environment. A robust governance structure attracts investments, it promotes sustainable growth, and it enables countries to withstand economic shocks.

Legitimacy and effectiveness in governance are crucial for the economic resilience of cities. Key indicators include the quality of data, transparency, accountability, accuracy and relevance, consistency and comparability, and accessibility, and ease of use. Statistical offices, regulatory agencies, and international organisations play important roles in ensuring legitimacy and effectiveness in governance. These factors foster trust, they support informed decision-making, and they create a favourable business environment. Ultimately, by prioritising these indicators, governance can contribute to the economic resilience of cities.

Political stability is a component of governance that has effects on economic resilience. It encompasses indicators such as the absence of political violence, government effectiveness, political rights and civil liberties, regime type, and economic stability. Actors involved in ensuring political stability include national governments, political parties, electoral commissions, judicial systems, international organisations, and civil society organisations. Political stability is crucial for economic resilience as it creates a favourable environment for businesses, it attracts investments, and it allows for the implementation of long-term economic policies.

Investing in infrastructure is a sub-category of government policies that is a component of governance, and it can have effects on economic resilience. It involves indicators such as gross fixed capital formation, public and private investment, infrastructure quality, connectivity, transportation systems, energy grids, communication networks, job creation, small business loans, targeted stimulus spending, innovative entrepreneurship, enabling system renewal, industry governance, organisational thickness, and entrepreneurship tradition. National governments, development banks, private sector partners, international organisations, and regional organisations are involved in infrastructure investment. Investing in infrastructure enhances productivity,

it promotes economic growth, it creates job opportunities, it attracts investments, it fosters innovation, and it strengthens the resilience of industries and economies.

Investing in human capital, including education, health, training, research and development, digital skills, and knowledge of the environment, is crucial for economic resilience. A well-educated population contributes to innovation and adaptability, while good health and access to healthcare reduce economic burdens. Training programs enhance skills and adaptability, research and development drive innovation, and digital skills are essential in the digital economy. Understanding and addressing environmental challenges also contribute to long-term economic sustainability. Collaboration among governments, institutions, businesses, and civil society is needed to invest in human capital and to enhance economic resilience.

Revenue generation is indeed an important factor in the economic resilience of cities. Indicators, such as taxes, fees, and grants, play a significant role in generating revenue for municipalities. All actors involved, including the municipal or local government, finance department, taxation department, and urban planning department, all contribute to revenue generation through their respective roles. Additionally, grants and funding agencies can also provide financial support for cities. It is important for cities to have a well-functioning finance department, budget office, auditing and internal control units, and oversight bodies to ensure proper management of revenue.

Expenditure control is another critical component of budget management and economic resilience. It involves monitoring and managing expenses to prevent them from exceeding the available funds. Key indicators, such as tracking spending patterns and analysing budget variances, help identify risks and enable corrective actions. The finance department collaborates with other departments to prioritise spending based on economic resilience goals. City managers and department heads are responsible for managing expenses and optimising resource allocation.

Debt management involves effectively managing and monitoring the city's debt to maintain financial stability. Key indicators, such as the debt-to-revenue ratio and the debt service coverage ratio, help to assess the city's ability to service its debt. The finance department develops and it implements debt management policies, it collaborates with other departments, and it monitors debt repayment. City managers and department heads make informed decisions regarding borrowing and they prioritise investments aligned with economic resilience goals. Oversight bodies provide accountability and transparency in debt management.

Cost recovery involves collecting user fees to cover the costs of public services, while reducing the burden on public budgets. The finance department develops policies and strategies for cost recovery, it collaborates with other departments, and it monitors its implementation. City managers and department heads make informed decisions on user fees and they prioritise investments accordingly. Oversight bodies ensure accountability and transparency in cost recovery practices.

Financial sustainability encompasses maintaining adequate reserve fund levels, efficient asset management, and long-term financial planning. Adequate reserves help cities to handle unexpected events, without compromising essential services. Efficient asset management maximises the value of assets and it generates revenue. Long-term financial planning ensures the strategic allocation of resources. Key actors in promoting financial sustainability include the finance department, city managers, and oversight bodies.

Efficiency and effectiveness are vital components of budget management that contribute to economic resilience in cities (Figure 1). Indicators, such as service delivery cost per capita and service quality ratings, help to measure and to evaluate these components. Efficient resource allocation ensures that cities can provide essential services to their residents while optimising financial sustainability. Service delivery cost per capita measures the efficiency of resource allocation in delivering services. It helps cities to assess the cost-effectiveness of their service provision and to identify areas for improvement. Service quality ratings measure the effectiveness of service delivery in meeting the needs and expectations of the residents.

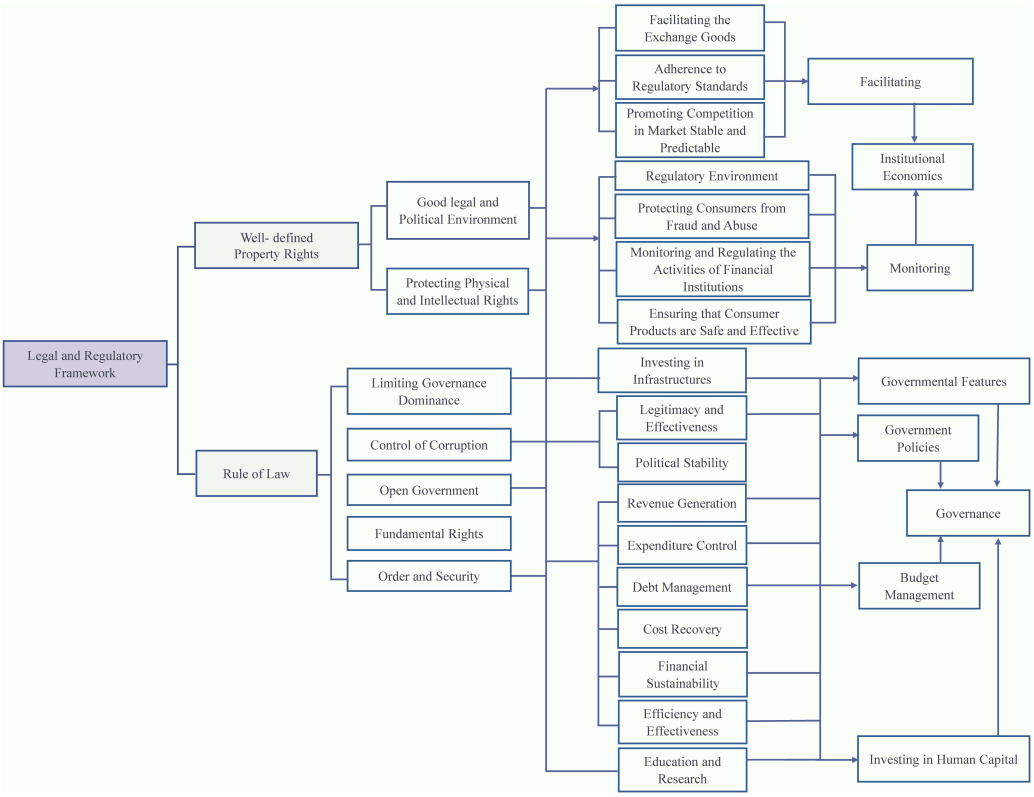

Figure 1. Institutional elements of economic resilience

Discussion

Institutional and economic resilience are two important elements in the resilience of cities against natural and man-made pressures and w stressors (Irani and Rahnamayiezekavat 2021). They not only play an important role in determining the level of resilience of cities but also their interaction and interdependence cannot be denied. A dynamic and effective urban economy is not possible without the management and governance institutions which provide a suitable platform for economic growth and development (Grindle 2004, Cruz et al. 2019, Raven et al. 2019). But a strong economy can provide a basis for urban managers and governors to plan and to strategize better.

Therefore, this research aimed to emphasise the relationship between the elements of economic resilience and institutional resilience. To this end, by referring to the theoretical and empirical literature, the research has tried to provide a comprehensive model for analysing the interactions and relationships between the different components of economic and institutional resilience, in addition to discovering the common elements that contribute to both. The results of this research can be used as a scientific document by policymakers and urban planners to benefit from it in their economic management policies and strategies. Therefore, the role of key actors in each component of the identified elements has been highlighted in this research.

To achieve the research goal, we formulated three questions, each aimed at explaining a key aspect of the main research issue. The first question addressed the necessity and importance of institutional foundations for the economic resilience of cities. The second question focused on the role of various institutional actors in ensuring economic resilience. We believed that identifying the actors' roles and positions, and their interactions with each other, in addition to determining the relationship between institutional resilience and economic resilience, plays a crucial role in policymaking, planning, and strategy development. The third question aimed to provide a final conclusion and summary of the first two questions. We sought to draw a clear structure of the relationship between various elements of institutional and economic resilience, and to develop a coherent theoretical model based on the existing literature.

To answer the first and second questions, which are related to the exploratory part of the related research objectives, an attempt was made to identify the important institutional elements and actors, through a comprehensive literature review based on the continuous comparison approach. The final result was a comprehensive classification of the elements and actors influencing economic resilience, which showed that the existence of institutional platforms and actors who manage institutional elements are important for economic resilience (Tkach et al. 2019, Buchen 2024).

One of the methodological approaches of the current research was the approach of alternative models or the design of a comprehensive conceptual framework, which was adopted to answer the last two questions of this approach. By using the categories and

concepts identified in the exploratory part, an analysis of the relationships between the different factors was done and a suitable conceptual model was drawn for it. Therefore, the researchers, relying on an important principle in the literature of urban planning, which considers the city as a complex system (Maranghi et al. 2020), composed of related parts that form a coherent whole within a regular process, tried a new conceptualisation of the relationship between institutional resilience and resilience. In this conceptualisation, the relationships between economic, managerial, governance, and legal institutions were analysed within a system composed of "intra-systemic", "extra-systemic", and "meta-systemic" components.

Conceptualisation shows that a resilient economy is formed by internal institutional elements that provide suitable conditions for facilitating economic activities and they exert the necessary supervision for protecting a healthy market (Suchek et al. 2021, Shavshukov and Zhuravleva 2023). These internal relations require institutional communication with policymaking and governance levels, which provide the necessary conditions for investment in infrastructure and human resources, and they manage various resources in a desirable way (Figure 2).

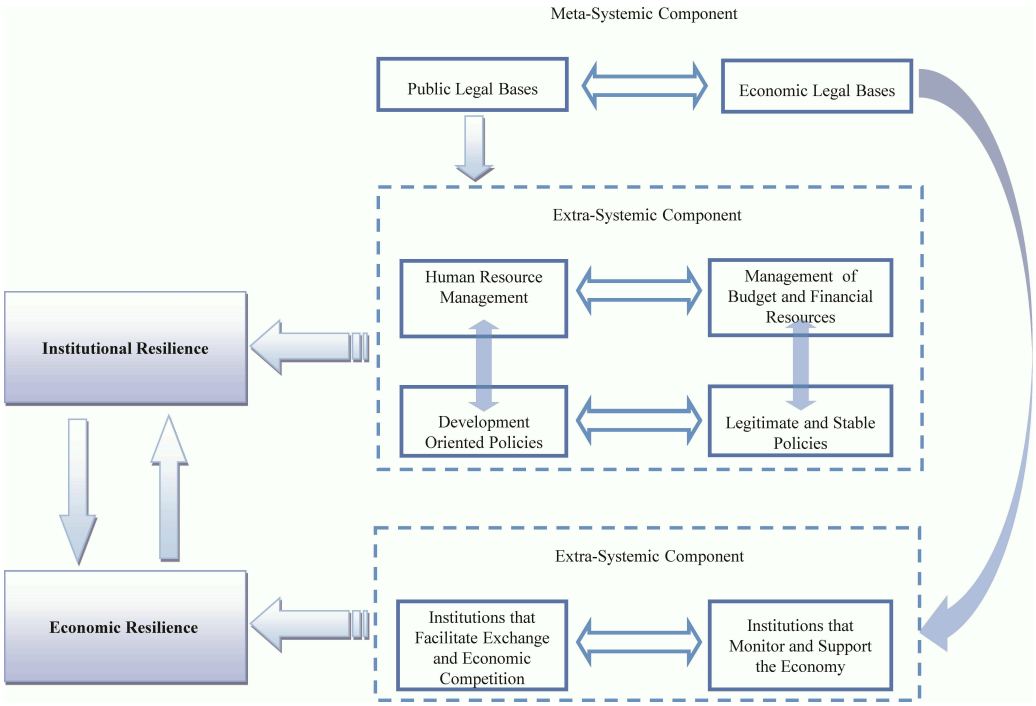

Figure 2. Conceptual framework of institutional and economic resilience

At this level, the existence of a responsive, transparent, stable, and legitimate governance system that can optimally mobilise resources and allocate them to effective

urban economic development is crucial. Internal and external institutional elements can sinergically interact with each other, strengthening a supra-systemic system, such as a legislative system that provides a suitable platform for their interaction. These meta-systemic institutions can create an economic growth atmosphere in two aspects: economic laws, and general laws. In the economic laws section, laws that are specific to economic activities, such as property rights protection, are included, and in the general laws section, policies related to macro-level policies in various fields provide environments of trust, enthusiasm, and success for investment and sustainable economic growth.

Intra-systemic Institutions

Institutional economics investigates the impact of institutions and social systems on economic development, acknowledging that economic activities are shaped by the governing rules, norms, and organisations (Spithoven 2019, Voigt 2019). Institutions provide structure and coordination for smooth economic interactions (Nolte 2010). Property rights are a key aspect, incentivising efficient resource utilisation (Kurpayanidi 2021). Market laws and regulations establish a framework for economic activities, ensuring fair competition, consumer protection, and transparency (Belwal et al. 2021, Saberi and Sadeghi 2022). Collaboration among institutions is crucial for the functioning of the economic system, resolving conflicts and supporting businesses and individuals (Folger et al. 2021). Effective coordination and efficient resource allocation are essential for smooth economic activities (Fastiggi et al. 2021, Mondal 2023), and institutional economics seeks to comprehend the interplay and impact of these factors on the economic outcomes (Aparicio et al. 2016, Martin 2017).

In the institutional economy, institutions play a vital role in fostering transparency and facilitating business transactions, thereby enabling the exchange of goods and services (Ahrens and Rudolph 2006). Business registration agencies play a vital role in simplifying the process of starting and registering businesses (Yun et al. 2019, Shah et al. 2023), offering entrepreneurs the essential legal and administrative assistance needed to establish their ventures, ultimately reducing obstacles to entry and fostering a culture of entrepreneurship (Porter 2020). Competition authorities are crucial institutions responsible for enforcing antitrust laws, safeguarding fair competition in the market (Ndukwe and Allison 2021), investigating and acting against anti-competitive practices like monopolies, cartels, and price-fixing, and ultimately protecting consumer interests, and fostering innovation and efficiency (Anderson et al. 2018).

Consumer protection agencies ensure fair treatment for consumers, by enforcing laws, by investigating complaints, and by acting against fraudulent businesses, ultimately maintaining market trust (Ramsay 2006). Tax authorities collect taxes, they ensure compliance, guide businesses, and prevent evasion, contributing to economic development (Brondolo 2009, Okafor 2012). Unemployment insurance agencies

support unemployed individuals, by administering benefits, by providing temporary financial assistance, and by aiding their transition back to work (Venn 2012, Carranza et al. 2020). Adherence to regulatory standards for product safety (Jnawali et al. 2016), environmental protection (Abbott and Snidal 2021), and labour practices (Abbott and Snidal 2021) is crucial for economic activities, to ensure consumer wellbeing, to protect the environment, to safeguard the workers' rights, and to maintain the market trust.

Environmental protection agencies enforce regulations and guidelines to monitor and to regulate the businesses' impact on the environment, while ensuring compliance with the environmental standards (Cai et al. 2020). Also, they play a crucial role in mitigating pollution (Pettipas et al. 2016), in promoting sustainable practices (Tan et al. 2011), and in preserving natural resources for future generations (Sands 2013).

Labour regulators and occupational safety and health agencies enforce labour laws, while ensuring fair and safe working conditions, and they monitor the compliance with labour standards, like minimum wage, working hours, and benefits (Bholat et al. 2018). CSR agencies encourage businesses to adopt ethical and responsible practices that exceed legal obligations and they offer guidance for enhancing their social and environmental impact (Setó-Pamies and Papaoikonomou 2016).

Different agencies work collaboratively to ensure fair competition (Yin 2017), to prevent anti-competitive behaviour, to protect consumers from false advertising and unfair business practices, and to provide support to businesses in markets. Promoting competition through minimising entry barriers (Hoskisson et al. 2013), encouraging innovation (Bloom et al. 2019, Shao et al. 2020), and protecting consumers are crucial for a level playing field (Anagnostopoulos 2018), lower prices (Falahat et al. 2020), increased choices (Eckhardt et al. 2019), and improved quality (Anwar and Abdullah 2021). Concentration and inelastic demand limit competition and harm the consumers, thus highlighting the importance of institutions and agencies in promoting competition and consumer protection. The enhancing of innovation is a multifaceted process with the collaboration of various entities, as patent and trademark offices play a crucial role in safeguarding rights and promoting innovation (Ayerbe et al. 2024).

Another important institutional principle in the development of commercial and economic markets is monitoring the system and processes of the market, while ensuring competition, which can protect consumer rights in addition to creating a fair competitive environment for economic agents. Regulatory agencies promote fair competition by addressing anticompetitive behaviour (Alemu 2018), by preventing market abuses (Owen et al. 2016, Ezrachi 2018), and by creating a stable legal environment (Tshuma 1999) to enable an effective business activity.

An effective method of market monitoring is the positive or incentive-based regulation, to encourage competition and commercial markets through various approaches, such as providing tax exemptions (Parc 2018), while removing unnecessary regulations (Porter 2020), and trade barriers (Li 2017). To achieve this, regulatory agencies should

continuously monitor the economic processes to provide insights and data on the market conditions, on the competition, and on the impact of policies.

Consumer protection agencies not only safeguard consumers against fraud and abuse but they also educate them about their economic rights and responsibilities, while instilling a sense of empowerment. Educational and informational agencies provide programs and resources to increase consumer financial literacy, knowledge of financial products, services, and risks (Eniola and Entebang 2017, Kaiser et al. 2025), and to enable more informed decisions and protection against fraudulent schemes.

Financial regulatory agencies, such as banking and security commissions, alongside government regulatory organisations, such as law enforcement and public prosecutors, help in preventing fraud (Wu et al. 2016), by ensuring market integrity (Myklebust 2020), and by protecting the consumers (Lee and Shin 2018). Also, non-governmental organisations develop and implement consumer protection initiatives, together with government agencies, financial institutions, and public education institutions (Goldsmith and Piscopo 2014, Buettner 2020).

Commercial organisations (e.g., industry associations and chambers of commerce) also promote fair business practices among their members, through ethical standards, codes of conduct, and resources for businesses to ensure compliance with consumer protection regulations (Utting 2005, Sawyer 2017).

Monitoring organisations control financial institutions by assessing their ability to repay debts (Barbera et al. 2017), by evaluating their liquidity risk management (Yadav and Shaikh 2023), by overseeing the asset quality (Hussien et al. 2019), by estimating the potential credit risks (Danisman et al. 2021), by calculating market stability (Briguglio et al. 2009), and by protecting the stability of the financial system (Hannig and Jansen 2010). Additionally, there are indicators to evaluate the compliance of these institutions with the economic laws and to meet the consumer needs, rights, and security, by testing the products and by addressing the public complaints.

Extra-systemic institutions

The extra-systemic institutions of the urban economic system are made up of economic institutions which are responsible to provide the necessary components for the proper functioning of the internal system. These components include raw materials, supplies, equipment, energy, and other resources that are essential for the production and distribution of goods and services within the urban economic system. Governance and management institutions are responsible for overseeing and for managing the external system section (Atmaja et al. 2022). They are tasked with policy formulation, resource management, and investment in financial, infrastructure, and human resources. This involves creating policies and regulations that promote the proper functioning of the external system section, while managing financial resources to ensure adequate funding for the necessary supplies and materials, by investing in

infrastructure to support the transport and distribution of goods and services, and by managing human resources to ensure an adequate workforce.

Governance features, which include various factors such as rule of law (Sutton 2008), transparency and efficiency (Lee et al. 2022), accountability (Dzigbede et al. 2022), and social participation (Terzo 2021), are considered a determining factor in creating institutional prerequisites for economic resilience. Social participation in decision-making processes requires a transparent and accountable governance system. All of these actions are achievable only if the political system is stable (Duan et al. 2022), human political rights are recognised (Monga et al. 2019), and there are political freedom (Sutton 2008) and economic stability (Bakhtiari and Sajjadieh 2018).

Respect for political rights and civil liberties, which involves safeguarding freedom of speech, assembly, and association, as well as the right to participate in political processes and to choose leaders through free and fair elections, is crucial for ensuring political stability. The influence of the political system type on political stability is significant, as democracies, with their focus on social participation, rule of law, and accountability, generally exhibit greater stability than autocratic regimes, although a political stability ultimately hinges on its capacity to meet its citizens' needs and aspirations, regardless of its form. Economic stability and political stability are closely linked (Kim 2010), with a strong economy improving living standards and reducing inequality, while economic instability can result in social and political unrest (Carmignani 2003, Altig et al. 2020). It is clear that the absence of such factors can lead to various crises in the political system, such as political violence (Leer et al. 2023), dissatisfaction (Graziano and Riszi 2016), and reduced quality and efficiency of organisations (Zhu et al. 2021). The effects of which can be observed in various areas, such as the economy, which can endanger economic resilience.

In addition to government features, government policies in investing in infrastructures, such as transportation systems (Chen and Rose 2018), energy networks (Dehghani 2023), and communication networks (Thaher et al. 2022), are important for economic resilience. These investments enhance connectivity, a vital factor in economic development, they stimulate trade growth, create new job opportunities, and particularly boost economic activities in construction and related industries. The effectiveness of infrastructure investments depends on the quality of the infrastructure, which requires governments to ensure well-planned and properly executed projects that meet the needs of the people, considering factors such as durability (Hu and Hassink 2020), reliability (Dormady et al. 2019), safety, and environmental sustainability (Rose 2017).

In addition to infrastructure investment, government policies can support economic resilience by implementing measures such as providing small business loans (Levine et al. 2025) and promoting innovative entrepreneurship (Wang et al. 2021). Job creation is essential for reducing unemployment and poverty, while small businesses

are often a significant source of employment and innovation. To effectively implement these policies, collaboration between various actors (Kakderi and Tasopoulou 2017) is necessary, with national governments taking a central role in formulating and implementing policies. Private sector partners (Lomboy et al. 2019), including construction companies, technology providers, and service providers (Kakderi and Tasopoulou 2017), can contribute with their resources and expertise to infrastructure projects. International organisations, such as the World Bank and the United Nations, can provide guidance, funding, and technical assistance (Jha et al. 2013). Regional organisations can facilitate cooperation and coordination among the countries in infrastructure development (Peng et al. 2020).

Budget management is an essential process that includes several components, such as revenue generation (Boyle 2014), expense control (Gong 2023), debt management (Briguglio et al. 2009), financial stability (Cho 2018), and efficiency and effectiveness (UN.ESCAP et al. 2022). Through budget management and effective expense control, organisations can allocate resources for economic development, they can prioritise expenses, control costs, and ensure alignment with organisational goals, ultimately leading to an efficient resource utilisation.

Another role that urban governance institutions can play in supporting economic resilience is investing in human development through the promotion of education, healthcare, training and development, research and development, and environmental knowledge (Osher et al. 2021). Education empowers individuals to develop the essential skills and expertise needed to excel in diverse tasks and occupations (Kivunja 2014), while enabling them to generate innovative ideas to solve intricate problems (Smith et al. 2015), and to offer improved solutions across multiple domains (Clarke 2015). Improving healthcare is crucial for productivity and economic resilience, as it enhances individual health, resulting in higher productivity, improved performance in daily activities and work (Zamfir (Avram) et al. 2022), and an increase in human capital (Barasa et al. 2018). Furthermore, healthcare measures that promote individual health and reduce medical treatments contribute to cost savings in healthcare (Rémy et al. 2015), by freeing up financial resources for other economic sectors and by facilitating investment in various areas.

Investment in research and development is another institutional necessity for economic resilience, as it helps to create new knowledge and innovative technologies that enable the economy to be updated and capable of facing new challenges (Audretsch and Lehmann 2016). Research and development can provide new strategies to confront economic challenges and risks, to create new employment opportunities, and to enable companies and industries to compete with domestic and foreign competitors through the creation of innovative technologies and process improvements.

Meta-systemic institutions

The "meta-systemic" institutions of the urban economy refer to the overall framework of policies, laws, and regulations that govern economic activities in cities. They also refer to the overall framework of policies, laws, and regulations that govern economic activities in cities and shape their dynamics, while influencing everything from urban planning and taxation to labour laws and environmental regulations (Pugh 2013, Zhang et al. 2020). The policies and regulations set by the government and other governing bodies influence the allocation of resources (Todeva 2013), the development of industries (Meghani and Kuzma 2011), the competitiveness of businesses (Abor et al. 2024), and the overall economic performance of the city (Dijkstra et al. 2013).

In a legal and regulatory framework, protecting individuals' property rights is crucial for ensuring investment and business growth in a stable and efficient market (Krever 2011, Clarke 2016). The existence of a fair and impartial judiciary system is essential for resolving property disputes (Chuang 2011, Merrill 2019), for upholding property rights (Gloppen 2014), for promoting justice (Petersmann 2008), stability, and economic prosperity (Brkić et al. 2020), and for serving as a check on potential abuses of power, as, without it, society would be vulnerable to arbitrary decision-making, insecurity, and a lack of trust in the legal system. Political corruption undermines economic resilience by diverting resources, by eroding trust, by impairing the business environment, by reducing public services, and by weakening the rule of law (Epse Bomba et al. 2023). It is important to have limitations on the government power and strong institutions in place to ensure fair competition and to prevent anti-competitive behaviours (Sengupta and Dube 2008, Soomro and Yuhui 2023).

Auditing, anti-corruption institutions, complaint offices, and election management organisations all play a crucial role in maintaining transparency and accountability in government actions. Corruption undermines the rule of law, and it erodes public trust in the government (McDevitt 2020, Vian 2020). It is essential to have robust anti-corruption measures in place (Owusu et al. 2019, Tacconi and Williams 2020), to address and to prevent corrupt practices, such as bribery, illegal payments, nepotism, favouritism, and preferential treatment in governmental decisions (Singh 2019).

Commissions and regulatory bodies play a crucial role in maintaining the integrity of the legal and supervisory framework, by setting and by enforcing ethical standards for government officials and public employees (Adeyemi et al. 2012, Evans 2012). Through the establishment of ethical guidelines, enforcement mechanisms, transparency promotion, guidance and training, whistleblower protection, monitoring and oversight, and collaboration with other agencies, commissions contribute to a culture of integrity, and they ensure that government actions are carried out in a fair and transparent manner.

Open government is a concept that emphasises transparency, accountability, and citizen participation in the functioning of the government (Evans and Campos 2013, Harrison and Sayogo 2014). The freedom of information commissions are independent bodies responsible for enforcing and for promoting the right to access information held by the public authorities (Hazell and Worthy 2010). They help to ensure that the citizens have the right to request and to receive information from the government, while promoting transparency and accountability.

Civil Society Organisations (CSOs) act as intermediaries between the citizens and the government, by facilitating the dialogue, by advocating for the citizen interests, by providing expertise, and by holding the authorities accountable (van den Boogaard et al. 2022). Their role is essential in promoting good governance, inclusivity, and transparency in the relationship between the citizens and the government.

Judicial watchdogs are organisations or individuals that monitor the judiciary system to ensure transparency, fairness, and adherence to the rule of law (Bhargava 2015). They play a crucial role in promoting judicial transparency, in preventing corruption, and in protecting the rights of the individuals within the judicial system (Frimpong 2017). Organised by international organisations or by civil society groups, the election observation missions are deployed to monitor and to assess the integrity and the fairness of elections, ultimately contributing to ensuring free and fair elections and promoting citizen trust in the electoral process (Gyekye-Jandoh 2016, Botchway 2018). These missions, often organised by international organisations or civil society groups, observe the electoral process, assess the compliance with democratic standards, and provide recommendations for improvement.

Fundamental rights, including civil and political rights, are indispensable for upholding the welfare, dignity, and autonomy of the individuals, while encompassing vital freedoms, like speech, assembly, association, fair trial, and political engagement (Young 2012, Ha and Phuong 2017). Human rights commissions play a crucial role in promoting and protecting the fundamental rights. These independent bodies are responsible for monitoring, investigating, and addressing human rights violations (Lacatus and Nash 2020). They can receive complaints, conduct inquiries, and make recommendations to ensure that individuals' rights are respected and protected.

CSOs also play a vital role in advocating for and in defending fundamental rights. They often work on the ground to raise awareness, to provide support to the victims, and to advocate for policy changes (Thiel 2017, Hess 2020). CSOs can engage in public campaigns, can provide legal assistance, and they can contribute to shaping public discourse on human rights issues (Gerő et al. 2020). The mass media also has a significant impact on the promotion and protection of fundamental rights. Journalists and media outlets play a crucial role in exposing human rights violations, in providing information to the public and in holding governments and institutions accountable (Asemah et al. 2013). Freedom of the press is essential for ensuring transparency, accountability,

and the free flow of information (Ullah 2009). Human rights courts and tribunals, such as regional human rights courts or international bodies, like the International Criminal Court, are responsible for adjudicating human rights cases (Fasciglione 2019). These courts provide a legal avenue for individuals and groups to seek justice and to hold perpetrators accountable for human rights violations.

Order, security, and the enforcement of contracts have a significant impact on economic resilience (Coaffee and Rogers 2008, Sánchez et al. 2016). When there is stability and security in society, businesses can operate without fear of disruptions or threats to their capital. This fosters trust and it encourages economic growth, by attracting investments, both domestic and foreign (Hajdari et al. 2024). The enforcement of contracts is crucial for economic resilience. Contracts provide a legal framework for business transactions, while ensuring that parties can rely on agreed-upon terms (Zhou and Poppo 2010, Berger-Walliser et al. 2011). When contracts are effectively enforced, businesses have confidence in conducting transactions and they engage in long-term planning (Bloomfield 2006, Harrison and Sayogo 2014). This predictability reduces uncertainties and risks, while promoting economic resilience (Luo 2008).

Law enforcement agencies play a role in economic resilience by preventing and addressing crimes, and by creating a safe environment for businesses (Achumba et al. 2013). This attracts investments and it encourages economic activities. A fair and impartial judicial system ensures that disputes can be resolved in a timely and just manner. When businesses have confidence in the legal system's ability to protect their rights and to resolve disputes fairly, they are more likely to invest and to engage in economic activities. Alternative Dispute Resolution (ADR) agencies and legal aid organisations also contribute to economic resilience (Bessy 2012, Kariuki 2015). ADR agencies provide efficient and cost-effective methods of resolving disputes outside of the court system, while saving businesses' time and resources (Sourdin et al. 2020, Okeke 2023).

This literature review, while comprehensive, has notable limitations. Firstly, it heavily relies on theoretical models and frameworks from the past literature, which may hinder practical application in real urban settings, as the lack of empirical testing through case studies or quantitative analysis presents a significant gap. Secondly, the research predominantly focuses on Western cities, limiting the applicability of the proposed framework to other cultural, economic, and institutional contexts, particularly in developing countries with different institutional structures. Furthermore, the dynamic nature of urban systems and the evolving relationship between institutional and economic resilience are not well captured in the current static framework, indicating a need for more research on the temporal aspects of resilience construction and the feedback loops between these elements.

Future studies should address these shortcomings: by conducting comparative case studies to empirically test the three-dimensional framework across various

urban contexts; by developing quantitative indicators to measure the effectiveness of institutional factors; by investigating how the interaction between institutional and economic resilience evolves during and after crises; by exploring the impact of emerging technologies and digital governance; and by comparing institutional designs across cultures. Additionally, it is essential to examine the specific institutions that facilitate coordination among different actors, and how to optimise these mechanisms to enhance overall urban resilience.

Conclusions

The research aims to explore the relationship between economic resilience and institutional resilience in cities. It emphasises the importance of both elements in determining the level of resilience of cities against various pressures and stressors. The study recognises that a dynamic and effective urban economy is not possible without management and governance institutions that provide a suitable platform for economic growth and development. Conversely, a strong economy can provide a basis for urban managers and governors to plan and to strategize better.

The research conducted a comprehensive literature review using the continuous comparison approach. Important institutional elements and actors influencing economic resilience were identified. The research found that the existence of institutional platforms and actors who manage institutional elements is crucial for economic resilience. The research also employed the approach of alternative models or the design of a comprehensive conceptual framework. This approach analysed the relationships between different factors, and it drew a suitable conceptual model. The researchers conceptualised the relationship between institutional resilience and economic resilience within a system composed of "intra-systemic", "extra-systemic", and "meta-systemic" components. Economic institutions were considered as internal system components influenced by external system components of management and governance, as well as meta-system components of the legal system.

The research demonstrated that intra-system institutions provide the suitable conditions for facilitating economic activities and they exert the necessary supervision for protecting a healthy market. These internal relations require institutional communication with policymaking and governance levels, which provide the necessary conditions for investment in infrastructure and human resources, and they manage various resources effectively. The existence of a responsive, transparent, stable, and legitimate governance system is crucial at this level. The meta-systemic legislative system provides a suitable platform for their interaction, which can create economic growth environments through economic laws specific to economic activities, and through general laws related to macro-level policies.

The research emphasised the role of the intra-systemic component of institutional resilience in shaping economic activities and in providing structure and coordination for smooth interactions. Property rights, market laws, and regulations establish a framework for economic activities, by ensuring fair competition, consumer protection, and transparency. Collaboration among institutions is essential for resolving conflicts and for supporting businesses and individuals.

The research also demonstrated the role of the extra-systemic component of institutional resilience in economic resilience. Governance and management institutions formulate policies, manage resources, and invest in financial, infrastructure, and human resources to ensure the proper functioning of the external system. The meta-systemic component of the urban economy is crucial for the overall functioning and the success of cities. It encompasses the policies, laws, and regulations that govern economic activities and that shape the dynamics of urban areas. These policies and regulations influence various aspects of the urban economy, including urban planning, taxation, labour laws, environmental regulations, and the overall economic performance of the city.

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Appendix

Table 1. Dimensions and institutional actors of economic resilience

Dimension	Components	Criteria	Indicators	Actors	References
Legal and regulatory framework	Well-defined property rights	Legal and political environment	Strength and clarity of property laws; the independence and efficiency of the judicial system; the level of corruption in the political system; firm routines and rules; market regulations.	Property laws; Judicial systems; Land registries; Contract enforcement mechanisms; Certified appraisers; Real estate agents; Tax assessors; Financial institutions; Government agencies; Conveyancers; Financial institutions; Technology providers.	Adger 2000; Gilbertson and Preston 2005; Briguglio et al. 2005; Kaufmann et al. 2011; Akee and Jorgensen 2014; Bakhtiari and Sajjadieh 2018; Ouattara and Standaert 2020; Bartke and Schwarze 2021; Hu and Wang 2022; Rimoli et al. 2023.
		Physical property rights	Land titles, and other forms of tangible property; land, machinery, vehicles, equipment		
		Intellectual property rights	Patents, copyrights, and trademarks; Property valuation.		
	Rule of law	Constraints on government powers	Accountability; responsibility; transparency.	Audit institutions; Anti-corruption agencies; Ombudsman offices; Electoral management bodies; Whistleblower protection agencies; Competition authorities; Regulatory bodies; Ethics commissions.	Millett et al. 2009; Kaufmann et al. 2011; Abass 2017; Engel et al. 2018; Rashid and Johara 2018.
		Absence of corruption	Predictability; no arbitrary power; bribery; illegal payments; nepotism and cronyism; favouritism in decisions of government officials; elimination of monopoly.		
		Open government	Public access to information; civic participation; complaint mechanisms; judicial transparency.	Freedom of information commissions; Civil society organisations; Judicial watchdogs; Election observation missions.	Callamard 2010; Darbishire 2010; Scassa 2014; Waddington et al. 2019; Androniceanu 2021; Simelio-Solà et al. 2021.
		Fundamental rights	Civil and political rights, such as freedom of speech and assembly; as well as social and economic rights, such as the right to education and healthcare.	Human rights commissions; Civil society organisations; Mass media; Human rights courts and tribunals.	Eide et al. 2001; Roth 2004; Conte and Burchill 2016; Ha and Phuong 2017; Li 2017.
		Order and security	Enforcement of contracts; effectiveness of law enforcement, and the judicial system.	Judicial systems; Alternative dispute resolution (ADR) agencies; Legal aid organisations.	Bernstein 1992; Porta et al. 2000; Beck and Levine 2005; Jappelli et al. 2005; Clarke 2016; Raskin 2017.

Dimension	Components	Criteria	Indicators	Actors	References
Institutional economy	Facilitation	Facilitating the exchange of goods and services	Ease of doing business; promoting transparency in market transactions.	Business registration agencies; competition authorities; consumer protection agencies; securities regulators; tax authorities; unemployment insurance.	North 1989; Ndukwe and Allison 2021; Jiahao et al. 2022.
		Adherence to regulatory standards and guidelines	Product safety and environmental protection; labour practices.	Product safety regulators; Environmental protection agencies; Labour regulators; Occupational safety and health agencies; Corporate social responsibility (CSR) agencies.	Lalon 2015; Gereffi and Lee 2016; Sodhi and Tang 2019; Wang et al. 2019; Abbott and Snidal 2021.
		Promoting competition in markets	No market concentration; entry barriers; innovation; consumer surplus; price elasticity of demand.	Antitrust/Competition Authorities; Regulatory agencies; Consumer protection agencies; Trade associations; Business registration agencies; Trade and investment promotion agencies; Industry development agencies; Intellectual property agencies; Research and development (R&D) agencies; Technology transfer offices; Incubators and accelerators; Patent and trademark offices; Education and training agencies; Consumer advocacy groups.	Lemley 2002; Sell 2003; Kaufmann et al. 2011; Block 2012; Baker and Salop 2015; Usman et al. 2015; Le and Harvie 2016; Saurabh 2017; Teitz and Stewart 2017; Bone et al. 2019; Woolley and MacGregor 2022; Araki et al. 2023.
	Monitoring	Stable and predictable regulatory environment	Tax incentives; deregulation; trade agreements.	Fiscal policy agencies; Economic development agencies; Regulatory agencies; Research and evaluation agencies.	Borenstein and Bushnell 2000; Morisset 2003; Mendonça et al. 2009; Kaufmann et al. 2011.
		Protecting consumers from fraud and abuse	Educating consumers; investigating and prosecuting; monitoring and enforcing regulations; providing resources and support; fostering collaboration.	Consumer protection agencies; Financial regulatory agencies; Education and training agencies; Government	Smith 2000; Ferrell 2004; Milne et al. 2004; Ishak and Zabil 2012.

Dimension	Components	Criteria	Indicators	Actors	References
				agencies; Non-governmental organisations (NGOs); Business organisations.	
		Monitoring and regulating the activities of financial institutions	Capital adequacy ratios; liquidity ratios; asset quality indicators; risk management indicators; market indicators; compliance indicators.	Regulatory agencies; Financial institutions.	Babihuga 2007; Jha and Hui 2012; Elsiefy 2013; Hess 2016; Alharbi 2017; Bholat et al. 2018.
		Ensuring that consumer products are safe and effective	Risk assessment; safety standards; testing and certification; recall systems; complaint reporting, and surveillance systems.	Consumer Product Safety Commissions; Institutes of Standards and Technology.	Thomas et al. 2006; Marucheck et al. 2011; Vance et al. 2015.
Governance	Governmental features	Legitimacy and effectiveness	Quality of data; transparency and accountability; accuracy and relevance; consistency and comparability; accessibility and ease of use.	Statistical Offices; Regulatory agencies; International organisations.	Pérez et al. 2005; Mahapatra et al. 2007; Lourenço et al. 2013; Lourenço 2015; Opanyi 2016.
		Political stability	Lack of political violence; government effectiveness; political rights and civil liberties; regime type; economic stability.	National governments; Political parties; Electoral commissions; Judicial systems; International organisations; Civil society organisations.	Rodrik 2000; Richards et al. 2001; Langbein and Knack 2010; Kaufmann et al. 2011; Lynch and Crawford 2012.
	Government policies	Investing in infrastructure	Gross fixed capital formation; public investment; private investment; infrastructure quality; connectivity; transportation systems; energy grids; communication networks; job creation; small business loans; targeted stimulus spending; innovative entrepreneurship; enabling system renewal; industry governance; organisational thickness; entrepreneurship tradition.	National governments; Development banks; Private sector partners; International organisations; Regional organisations.	Reynolds 2009; Sutherland et al. 2009; Seneviratne and Sun 2013; Gherhes et al. 2018; Grillitsch 2019; Bardt et al. 2020; Gohar and Nencioni 2021; Hu and Wang 2022.
	Budget management	Revenue generation	Taxes; fees; grants.	Municipal or local government; Finance department; Taxation department; Urban planning department; Grants and funding agencies; Citizens	Folz and Lyons 1986; Ferguson 1993; Tanzi 2000; Serageldin et al. 2008; Bassanini and Reviglio 2011; Zhao and Cao 2011; Aish-
		Expenditure control	Monitoring and managing expenses to ensure that they do not exceed the available funds.		
		Debt management	Debt-to-revenue ratio, and debt service coverage ra-		

Dimension	Components	Criteria	Indicators	Actors	References
			tio.	and businesses; Finance department; Budget office; Auditing and internal control units; Oversight bodies.	warya 2012; Uhunmwuangho and Aibieyi 2013; Lupala 2015; Gorina et al. 2018; Trussel and Patrick 2018; Tan and Taeihagh 2020; Faraji et al. 2021; Gibson 2022.
		Cost recovery	Cost recovery ratio, and user fee collection rate.		
		Financial sustainability	Reserve fund levels; asset management; long-term financial planning.		
		Efficiency and effectiveness	Service delivery cost per capita; service quality ratings.		
	Investing in human capital	Education promoting; Health, training and development; Research and development; Digital skills; Knowledge of the environment; Broader agendas	Literacy rates; enrolment rates; completion rates; life expectancy; infant mortality rates; access to healthcare; availability of training programs; participation rates; science, technology, engineering, mathematics (STEM) education; internet access; digital literacy rates; participation in online learning.	National governments; Non-governmental organisations (NGOs); International organisations; Private sector; Communities.	Bozbura et al. 2007; Marimuthu et al. 2009; Oluwatobi and Ogunrinola 2011; Sethi et al. 2019; Kazemian et al. 2020; Grigorescu et al. 2021; Adeleye et al. 2022; Hu and Wang 2022.

The Impact of Public Transportation on the Reduction of Greenhouse Gas Emissions in the United States

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Abstract: Greenhouse gases (GHGs) contribute to global warming and climate change by trapping heat in the Earth's atmosphere. The U.S. Environmental Protection Agency (EPA) states that transportation accounted for 28.4% of the total GHG emissions in 2022, making it a significant contributor. Decreasing personal vehicle travels can help reduce GHG emissions, and using public transportation is a viable way to achieve it. This study evaluates the impact of public transportation on reducing GHG emissions in the U.S. and it included 292 urban areas with public transportation services, divided into two groups, based on whether the metropolitan population is over or under one million. The analysis considered data on: GHG emissions, with a 0.1° by 0.1° resolution; public transportation usage (passenger miles travelled); and on workers commuting to work using private vehicles. The findings from the regression analysis indicated that: (1) public transportation usage reduces GHG emissions, although the effect is minimal; (2) commuting to work using private vehicles increases GHG emissions, which has a greater impact than public transportation usage; and (3) both factors explain more variance in GHG emissions in urban areas with populations over one million compared to those with populations under one million. These findings align with the existing literature, demonstrating that public transportation usage can decrease GHG emissions by 0.77% in urban areas with populations over one million, and by 1.03% in those with populations under one million.

Keywords: greenhouse gas emissions; public transportation; commuting to work; metropolitan areas

Introduction

Increased greenhouse gas (GHG) emissions have led to several adverse environmental impacts, such as global warming and climate change (Intergovernmental Panel on Climate Change 2021), which in turn negatively affect our health and economy. For example, rising temperatures pose health risks for vulnerable populations due to excessive heat (Vose et al. 2017). GHG emissions also contribute to poor air quality, resulting in respiratory health issues (Nolte et al. 2018). Rising sea level caused by global warming threatens coastal communities and ecosystems (Fleming et al. 2018).

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Additionally, climate change can intensify extreme weather events, such as droughts and floods, leading to property loss and societal disruption (Ebi et al. 2018). These climate change events further exacerbate inequalities among various population groups, as they are impacted differently by these occurrences (Reckien et al. 2017).

According to the International Energy Agency (2023), transportation contributed 23% of global CO_2 emissions in 2022. In the United States, the transportation sector was the largest source of GHG emissions, accounting for 28.4% of the total emissions in 2022; followed by the electricity production sector (24.9%), the industry sector (22.9%), then the agriculture, commercial, and residential sectors (U.S. Environmental Protection Agency 2024a). In this case, the transportation sector includes highway and passenger vehicles, air travel, marine transportation, and rail, which use fossil fuels, such as gasoline and diesel, to transport people and goods (U.S. Environmental Protection Agency 2024b). Among these transportation sources, automobiles have become a major contributor to GHG emissions, particularly CO_2 (Medina and Tarlock 2010), due to the heavy reliance on cars in the U.S.

Transportation-related emissions across the U.S. reflect regional differences in population growth, economic activity, and urban development patterns (U.S. Environmental Protection Agency 2025). State-level policy initiatives also contribute to regional differences in transportation emissions. For example, western states—such as California, Oregon, and Washington—have implemented targeted legislation aimed to limit GHG emissions from the transportation sector (Lewis et al. 2018).

Geographically, cities and urban areas contribute a great deal of GHG emissions (Hoornweg et al. 2011, Karimipour et al. 2021), due to high population and activity concentrations. According to the 2020 Census, approximately 80% of the U.S. population resides in urban areas (U.S. Census Bureau 2022). The movement of people and goods within and among urban areas requires transportation which leads to increased GHG emissions. Researchers have studied urban GHG emissions and they proposed mitigation strategies for the transportation sector. For example, achieving a better balance between jobs and housing within urban areas can help to reduce the commuting distance and the vehicle miles (Cervero 1989, Lee and Lee 2020). Pushing jobs and population to transit-oriented nodes or corridors can lessen auto dependency (Crane 1996, Kay et al. 2014). Implementing mixed-use and compact development can improve walkability and minimise travel distance (Brownstone and Golob 2009, Cervero and Murakami 2010, Klungboonkrong et al. 2017). Adopting Intelligent Transportation System (ITS) technologies can improve transportation efficiency and lower environmental impacts (Barth et al. 2015).

Compared to an average single-occupancy vehicle, public transportation produces less GHG emissions per passenger mile (Federal Transit Administration 2010), making it a more environmentally friendly mode of travel. As of 2019, approximately 5% of U.S. commuters utilised public transportation; among them, bus was the most commonly

used mode (46.3%), followed by subway or elevated rail (37.7%), long-distance train or commuter rail (11.8%), and others (4.1%), like light rail and ferry (Burrows et al. 2021). Public transportation usage pattern varies significantly by regions in the U.S. As summarised by Burrows et al. (2021), in the metropolitan areas of the Northeast, 35.5% of workers used public transportation — substantially higher than the Midwest (7.1%), West (6.3%), and South (3.5%). Roa and Lima (2023) conducted a study on public transportation usage in California and found that a person riding a bus reduces 43% of GHG emissions compared to driving a car. So, reducing personal vehicle travel is crucial to lowering GHG emissions, and utilising public transportation offers an effective alternative. Implementing efficient public transportation services (Ali et al. 2021) and encouraging their use (Bleviss 2021) can help decrease the reliance on personal vehicles, thereby reducing GHG emissions.

While the existing literature has established that public transportation is a more sustainable alternative to personal vehicle travel for reducing GHG emissions, there is a limited understanding of the quantitative impact of public transportation on reducing GHG emissions in urban areas of different population sizes. This study is designed to address this gap by developing a regression model to assess GHG emissions from road transportation in 292 U.S. urban areas. It focuses on two predictor variables: public transportation usage, and personal vehicle travel. More importantly, it contributes to the literature by offering a quantitative assessment of the extent to which public transportation reduces GHG emissions. In specific, this study aims to:

1. Develop a dataset of GHG emissions from road transportation in the U.S;
2. Create a predictor variable to measure public transportation usage: per capita passenger miles travelled (PMT) via public transportation;
3. Create a predictor variable to measure personal vehicle travel: the percentage of workers who drive to work using their private vehicles;
4. Investigate the impact of public transportation usage on reducing GHG emissions in urban areas while controlling for the influence of personal vehicle travel;
5. Discuss mitigation strategies that can help to reduce GHG emissions.

Methodology

GHG emissions from road transportation

The dataset for GHG emissions from road transportation was based on the Emissions Database for Global Atmospheric Research (EDGAR), which is the European Commission's in-house global GHG emissions inventory (European Commission 2024). EDGAR provides global annual sector-specific GHG emissions data in 0.1° by 0.1° data points, available in a text file format. This dataset includes the latitude and longitude coordinates of data points and their associated tonnage of GHG emissions. The coor-

dinates were geocoded into a data layer using ArcGIS Pro (Figure 1). GHG emissions related to road transportation are reported under sector 1A3b in the EDGAR database (European Commission 2024). GHG emissions in this sector primarily consist of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). In 2022, CO_2 accounted for 99.98% of the sector's total GHG emissions (European Commission 2024). The combined tonnage of these gases represents the annual GHG emissions from road transportation.

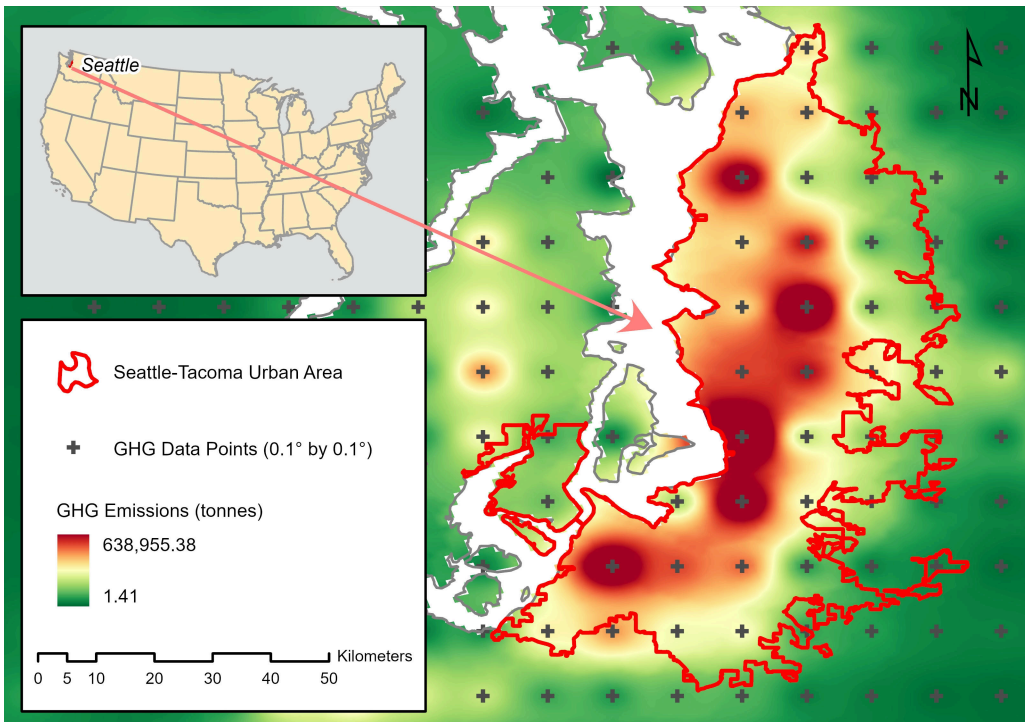

Figure 1. 2022 GHG emissions (data points in 0.1° by 0.1° grids) across the Seattle-Tacoma Urban Area in the U.S. Source: European Commission (2024)

A raster dataset of GHG emissions from road transportation was created to estimate the emissions in urban areas. This resulted from applying ArcGIS Pro's Inverse Distance Weighting (IDW) interpolation method (ESRI 2023) to the EDGAR data points (European Commission 2024) within the U.S. with a 1 km by 1 km resolution. The resulting dataset contains the spatial distribution of GHG emissions from road transportation across the U.S. (Figure 2). This dataset was then intersected with the 292 selected urban areas to calculate the total tonnage of GHG emissions in each urban area.

Since the 2022, GHG emissions dataset from EDGAR is the most recent available at the time of this study, efforts were made to obtain the datasets of the predictor variables from the same year.

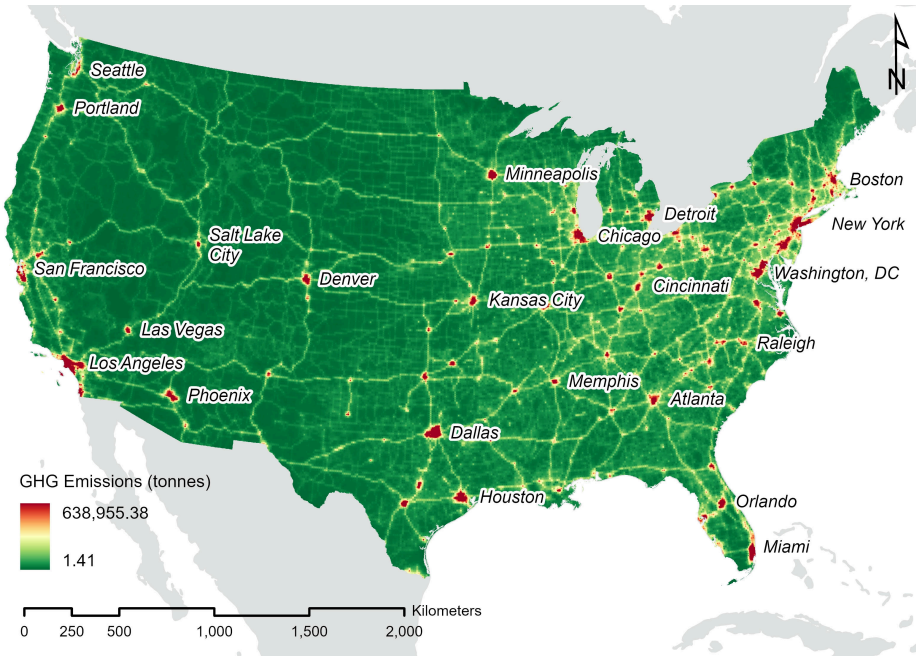

Figure 2. Spatial distribution of 2022 GHG emissions from road transportation (1 km by 1 km resolution), in the contiguous U.S. Source: European Commission (2024)

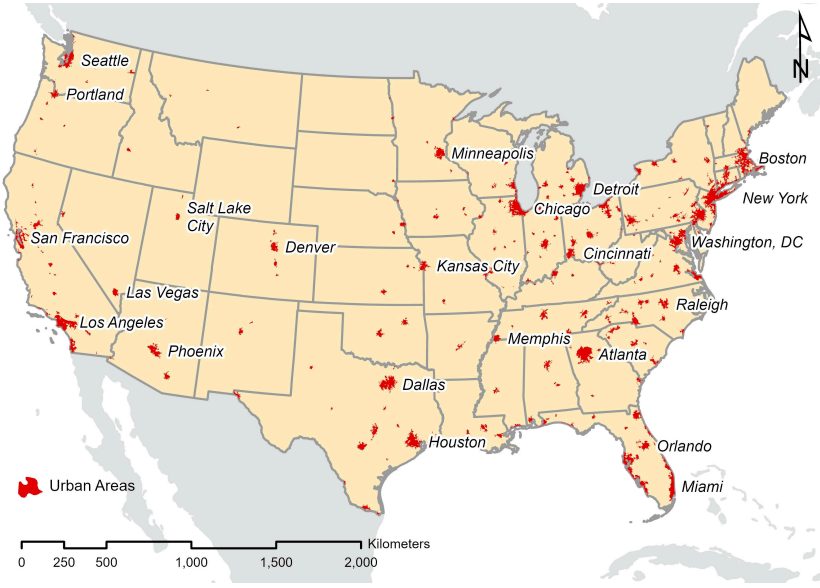

Figure 3. Selected urban areas with public transportation services (N=292) in the U.S. Source: Federal Transit Administration (2022)

Passenger miles travelled (PMT) via public transportation

The 2022 public transportation service dataset was obtained from the National Transit Database – NTD (Federal Transit Administration 2024). In 2022, NTD reported that 464 urban areas in the U.S. provided public transportation services. Out of the 464 urban areas, 292 logged the total passenger miles travelled (PMT) via public transportation. Since PMT is an important factor in assessing public transportation use, these 292 urban areas were selected to serve as valid cases in the study (Figure 3).

Commuting to work by private vehicles

Another key variable examined in the study was the utilisation of private vehicles as means of transportation in commuting to work. It is based on the B08119 table of the 2022 American Community Survey (ACS) – 5-year estimates at urban area level (U.S. Census Bureau 2024a). The B08119 table was downloaded using the Advance Search portal (U.S. Census Bureau 2024b), and it reports the number of workers who drive to work using their cars, trucks, or vans. Although the means of transportation for non-work purposes were not available, the B08119 table offered the opportunity to construct a proxy variable to measure the utilisation of private vehicles.

Operationalisation of variables

Due to the various sizes of population in urban areas, the dependent variable was operationalised by dividing an urban area's total GHG emissions related to road transportation by the urban area's population. It helped to compare the GHG emissions of urban areas regardless of their population sizes. This dependent variable was denoted as *GHG_per_capita*, which stands for the annual GHG emissions in tonnes per capita. Similarly, an urban area's total passenger miles travelled (PMT) was divided by its population to derive the independent variable *PMT_per_capita*. The other independent variable examined in this study was denoted as *Drive2Work_pct*. It was operationalised by dividing an urban area's workers who drive to work using their private vehicles by the urban area's total number of workers. *Drive2Work_pct* was computed in percentage form, which served to measure the utilisation of private vehicles.

GHG_per_capita across 292 urban areas in the U.S. ranged from 3.12 to 235.14 tonnes per capita, with an average of 88.16 (Table 1). It varies greatly by region, with the Northeast exhibiting the highest average at 111.66 tonnes per capita, compared to the West, which had the lowest at 51.63. For *PMT_per_capita*, the national average in the U.S. was 58.06 passenger miles per capita, with the West reporting the highest regional average of 93.34, and the Midwest the lowest at 39.08. Regarding *Drive2Work_pct*, on average, 74.58% of U.S. workers drive to work, with little variation across regions: 76.59% in the Midwest, 76.20% in the South, 72.81% in the Northeast, and 71.27% in the West.

Table 1. Table: Descriptive statistics of variables and their log transformations for the U.S. and its regions

	Variable	Min.	Max.	Mean	Std. Dev.	Skewness	Kurtosis
United States (N=292)	*GHG_per_capita*	3.12	235.14	88.16	40.77	0.32	−0.28
	ln_GHG_per_capita	1.14	5.46	4.34	0.57	−1.22	2.96
	PMT_per_capita	0.37	1,750.99	58.06	123.14	9.90	126.17
	ln_PMT_per_capita	−1.00	7.47	3.45	1.03	0.03	1.78
	Drive2Work_pct	45.23	87.71	74.58	6.68	−1.41	2.94
	ln_Drive2Work_pct	3.81	4.47	4.31	0.10	−1.90	5.51
Northeast Region (N=40)	*GHG_per_capita*	57.19	179.20	111.66	33.66	0.40	−0.60
	ln_GHG_per_capita	4.05	5.19	4.67	0.31	−0.13	−0.82
	PMT_per_capita	1.79	498.38	74.85	96.23	2.89	9.60
	ln_PMT_per_capita	0.58	6.21	3.75	1.14	−0.54	1.56
	Drive2Work_pct	45.52	81.69	72.81	6.92	−2.19	5.93
	ln_Drive2Work_pct	3.82	4.40	4.28	0.11	−2.65	8.63
Midwest Region (N=71)	*GHG_per_capita*	25.12	166.97	90.95	36.66	0.13	−0.84
	ln_GHG_per_capita	3.22	5.12	4.42	0.46	−0.66	−0.26
	PMT_per_capita	2.27	399.48	39.08	51.15	5.50	36.40
	ln_PMT_per_capita	0.82	5.99	3.32	0.78	0.23	2.32
	Drive2Work_pct	59.84	87.52	76.59	5.81	−1.23	1.00
	ln_Drive2Work_pct	4.09	4.47	4.34	0.08	−1.40	1.38
West Region (N=74)	*GHG_per_capita*	3.12	121.36	51.63	26.39	0.66	−0.22
	ln_GHG_per_capita	1.14	4.80	3.79	0.60	−1.22	3.87
	PMT_per_capita	7.17	1,750.99	93.34	216.15	6.67	49.33
	ln_PMT_per_capita	1.97	7.47	3.85	1.02	0.72	1.25
	Drive2Work_pct	45.23	82.01	71.27	7.70	−1.15	1.54
	ln_Drive2Work_pct	3.81	4.41	4.26	0.12	−1.57	3.18
South Region (N=107)	*GHG_per_capita*	20.91	235.14	102.78	37.65	0.40	0.54
	ln_GHG_per_capita	3.04	5.46	4.56	0.41	−0.91	1.38
	PMT_per_capita	0.37	323.08	39.99	52.63	3.40	13.81
	ln_PMT_per_capita	−1.00	5.78	3.16	1.05	−0.31	1.80
	Drive2Work_pct	55.71	87.71	76.20	5.24	−0.95	1.94
	ln_Drive2Work_pct	4.02	4.47	4.33	0.07	−1.29	3.17

GHG_per_capita: annual GHG emissions in tonnes per capita
ln_GHG_per_capita: log transformation of *GHG_per_capita*
PMT_per_capita: passenger miles travelled (PMT) per capita
ln_PMT_per_capita: log transformation of *PMT_per_capita*
Drive2Work_pct: percentage of workers who drive to work
ln_Drive2Work_pct: log transformation of *Drive2Work_pct*

The regression analysis assumed that the variables followed a reasonably normal distribution. Before specifying the regression model, the distribution shapes of the variables were examined. When a distribution is skewed, a log transformation may help

to normalise it and to make it more normally distributed, indicated by a skewness that is closer to zero. Consequently, the skewness statistics were analysed to determine if a log transformation would help a variable to become more normally distributed.

The skewness statistics indicated that *GHG_per_capita* and *Drive2Work_pct* were further skewed by a log transformation. The skewness of *PMT_per_capita* decreased from 9.90 to 0.03 by a log transformation, indicating a closer fit to a normal distribution.

Figures 4, 5, and 6 present three pairs of normal Q-Q plots to illustrate the effects of log transformation on the variables. In the case of *GHG_per_capita*, the data points in its normal Q-Q plot lie mostly along the diagonal line; and *ln_PMT_per_capita*, the log transformation of *PMT_per_capita*, exhibits a similar pattern.

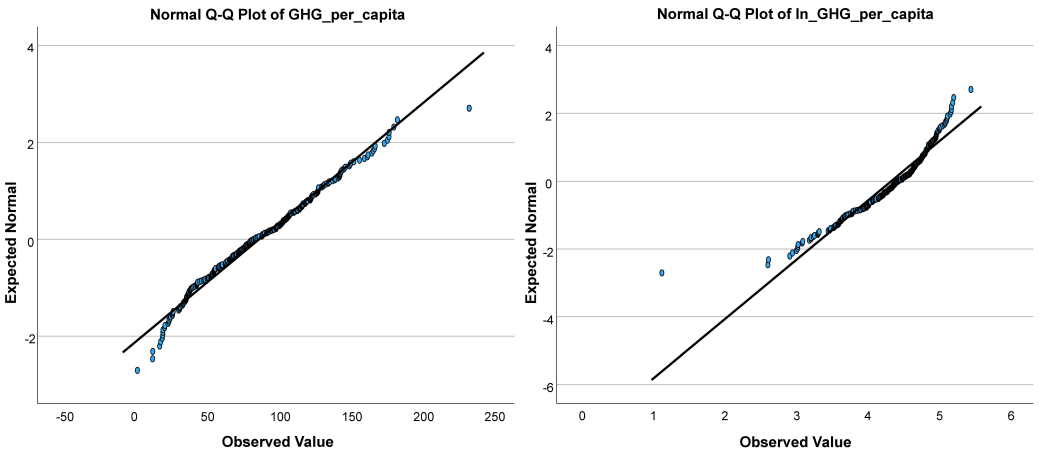

Figure 4. Normal Q-Q plots: Drive2Work_pct vs. ln_Drive2Work_pct (log transformation of Drive2Work_pct)

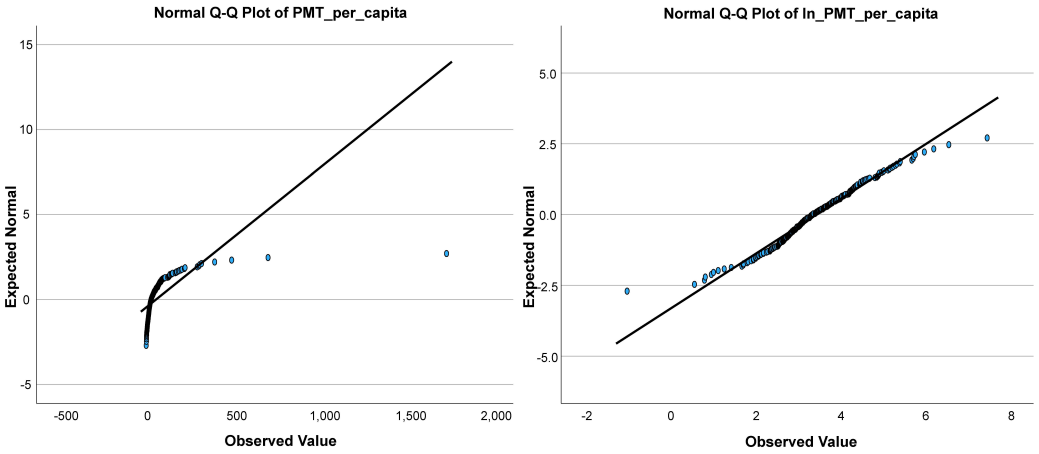

Figure 5. Normal Q-Q plots: PMT_per_capita vs. ln_PMT_per_capita (log transformation of PMT_per_capita)

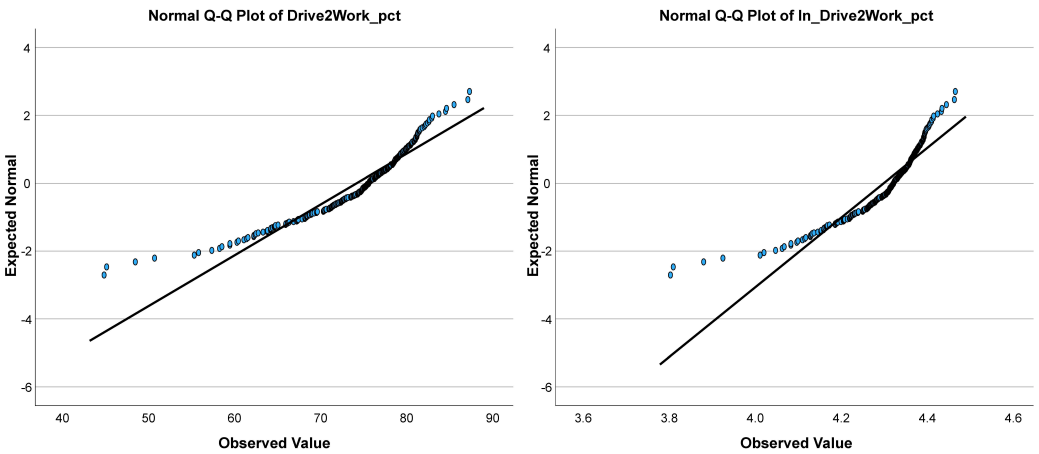

Figure 6. Figure 6. Normal Q-Q plots: Drive2Work_pct vs. ln_Drive2Work_pct (log transformation of Drive2Work_pct)

Regression model specification

Considering the skewness statistics and the normal Q-Q plots, a regression model was developed to analyse the impacts of *ln_PMT_per_capita* and *Drive2Work_pct* on *GHG_per_capita*. This model provided insights into the direction and magnitude of the influence of these independent variables on the GHG emissions. The regression model was formulated as:

$$GHG\_per\_capita(predicted) = b_0 + b_1^* ln\_PMT\_per\_capita + b_2^* Drive2Work\_pct \quad (1)$$

The United States has a very car-centric transportation system, with public transportation being relatively sparse in less populated urban areas. Recognising the differences in population size and the level of public transportation service, 292 of the selected urban areas were classified into two groups: urban areas with populations under one million (N = 248), and urban areas with populations over one million (N=44). The regression analysis was applied to both groups of urban areas to study the effects of *ln_PMT_per_capita* and *Drive2Work_pct* on *GHG_per_capita*.

On average, urban areas with populations over one million tended to have a higher *GHG_per_capita* (116.92), than those with populations under one million – 83.05 (Table 2). Urban areas with populations over one million also have a higher *ln_PMT_per_capita* (4.14), than those with populations under one million (3.33). However, *Drive2Work_pct* was lower in urban areas with populations over one million (69.38%), than those with populations under one million (75.50%).

In addition to the regression analysis, the part correlations of the independent variables *ln_PMT_per_capita* and *Drive2Work_pct* were computed and examined in SPSS.

The part correlation, or semi-partial correlation, measures the relationship between an independent variable and the dependent variable, while controlling for the effect of other independent variables. In other words, it removed the effect of control variables on an independent variable, so that we could examine the unique variance that an independent variable can explain in relation to the total variance in the dependent variable *GHG_per_capita*.

Table 2. Descriptive statistics of urban areas with populations under one million and those with populations over one million

	Variable	Min.	Max.	Mean	Std. Dev.	Skewness	Kurtosis
Urban areas with a population of less than one million (N=248)	*GHG_per_capita*	3.12	235.14	83.05	40.61	0.53	0.04
	ln_PMT_per_capita	−1.00	7.47	3.33	1.03	0.12	2.28
	Drive2Work_pct	45.23	87.71	75.50	6.13	−1.45	3.27
Urban areas with a population over one million (N=44)	*GHG_per_capita*	50.43	184.89	116.92	27.88	−0.07	0.08
	ln_PMT_per_capita	2.70	5.74	4.14	0.78	0.30	−0.74
	Drive2Work_pct	45.52	80.30	69.38	7.29	−1.46	2.49

GHG_per_capita: annual GHG emissions in tonnes per capita
ln_PMT_per_capita: log transformation of passenger miles travelled (PMT) per capita
Drive2Work_pct: percentage of workers who drive to work

Results

Regression analysis

Based on Equation (1), the regression analysis was performed on both groups of urban areas (Table 3). According to the F values, both models were statistically significant, with an F value of 7.891 ($p < 0.001$) for urban areas with populations under one million, and 7.007 ($p = 0.002$) for those with populations over one million. However, *ln_PMT_per_capita* and *Drive2Work_pct* only accounted for 6.05% ($R^2 = 0.0605$) of the variance in *GHG_per_capita* for urban areas with populations under one million, but 25.47% ($R^2 = 0.2547$) for those with populations over one million. This suggests that *GHG_per_capita* is more sensitive to variations in *ln_PMT_per_capita* and *Drive2Work_pct* in urban areas with populations over one million, compared to those with populations under one million.

The regression coefficient and the beta value can help to uncover the effect of independent variables on the dependent variable. The regression coefficient associated with an independent variable indicates the change in the dependent variable when the independent variable changes by one unit. For urban areas with populations under one million, an increase of one unit in *ln_PMT_per_capita* would result in an annual reduction of 4.1311 tonnes of GHG emissions per capita, while for those with populations

over one million, the reduction is 4.8985 tonnes. Conversely, a one percent increase in *Drive2Work_pct* would lead to an annual increase of 1.3159 tonnes of GHG emissions per capita for urban areas with populations under one million, and 1.5004 tonnes for those with populations over one million.

Table 3. Regression analysis of GHG emissions from road transportation

							Collinearity Statistics	
	Ind. Variable	Coeff.	Std. Error	beta	t	Sig.	Tolerance	VIF
Urban areas with population less than one million (N=248)	(Constant)	−2.5376	35.0336		−0.0724	0.9423		
	ln_PMT_per_capita	−4.1311	2.5254	−0.1045	−1.6358	0.1032	0.9405	1.0633
	Drive2Work_pct	1.3159	0.4228	0.1987	3.1120	0.0021	0.9405	1.0633
	Multiple R = 0.2460 R^2 = 0.0605 Adjusted R^2 = 0.0529 F = 7.891 (p < 0.001)							
Urban areas with population over one million (N=44)	(Constant)	33.0975	82.0103		0.4036	0.6886		
	ln_PMT_per_capita	−4.8985	7.5166	−0.1366	−0.6517	0.5182	0.4137	2.4172
	Drive2Work_pct	1.5004	0.8015	0.3924	1.8720	0.0683	0.4137	2.4172
	Multiple R = 0.5047 R^2 = 0.2547 Adjusted R^2 = 0.2184 F = 7.007 (p = 0.002)							

Dependent Variable: *GHG_per_capita:* annual GHG emissions in tonnes per capita
Independent Variables:
- *ln_PMT_per_capita*: log transformation of passenger miles travelled (PMT) per capita
- *Drive2Work_pct*: percentage of workers who drive to work

The beta value is a standardised regression coefficient. It indicates the change (in standard deviations) in the dependent variable when the independent variable changes by one standard deviation. Since beta values are based on standard deviations, they make it possible to cross-compare the effects of the independent variables (measured in different units) on the dependent variable. Due to their larger effects, *ln_PMT_per_capita* and *Drive2Work_pct* had a greater influence on *GHG_per_capita* in urban areas with populations over one million (beta values of 0.1366 and 0.3924), compared to those with populations under one million (beta values of 0.1045 and 0.1987). Between the two independent variables, *Drive2Work_pct* was more impactful on the *GHG_per_capita* than the *ln_PMT_per_capita*, in both types of urban areas. Specifically, for urban areas with populations under one million, an increase of one standard deviation in *ln_PMT_per_capita* would result in a reduction of 0.1045 standard deviations of *GHG_per_capita*; for those with populations over one million, the reduction was 0.1366 standard deviations. Conversely, an increase of one standard deviation in *Drive2Work_pct* would lead to an increase of 0.1987 standard deviations of *GHG_per_capita* for urban areas with populations under one million, and 0.3924 standard deviations for those with populations over one million.

As part of the regression analysis, collinearity among the independent variables was also examined. An important statistic that measures collinearity is the vari-

ance inflation factor (VIF). For urban areas with populations under one million, *ln_PMT_per_capita* and *Drive2Work_pct* had a VIF value of 1.0633. In contrast, for urban areas with populations over one million, the VIF value for *ln_PMT_per_capita* and *Drive2Work_pct* is 2.4172. Since the VIF values were relatively low (=less than 10; Regorz 2020), the regression model did not exhibit a collinearity issue.

The regression residual scatterplots (Figure 7) offered additional insight into the regression models for urban areas with populations less than one million (N=248) versus those over one million (N=44). Urban areas with populations over one million tended to exhibit higher predicted *GHG_per_capita* values, as reflected by their clustering toward the right side of the x-axis. However, the residuals for areas under one million showed a wider spread around zero on the y-axis, indicating that the regression model performed more reliably for larger urban areas, as reflected by the tighter residual spread.

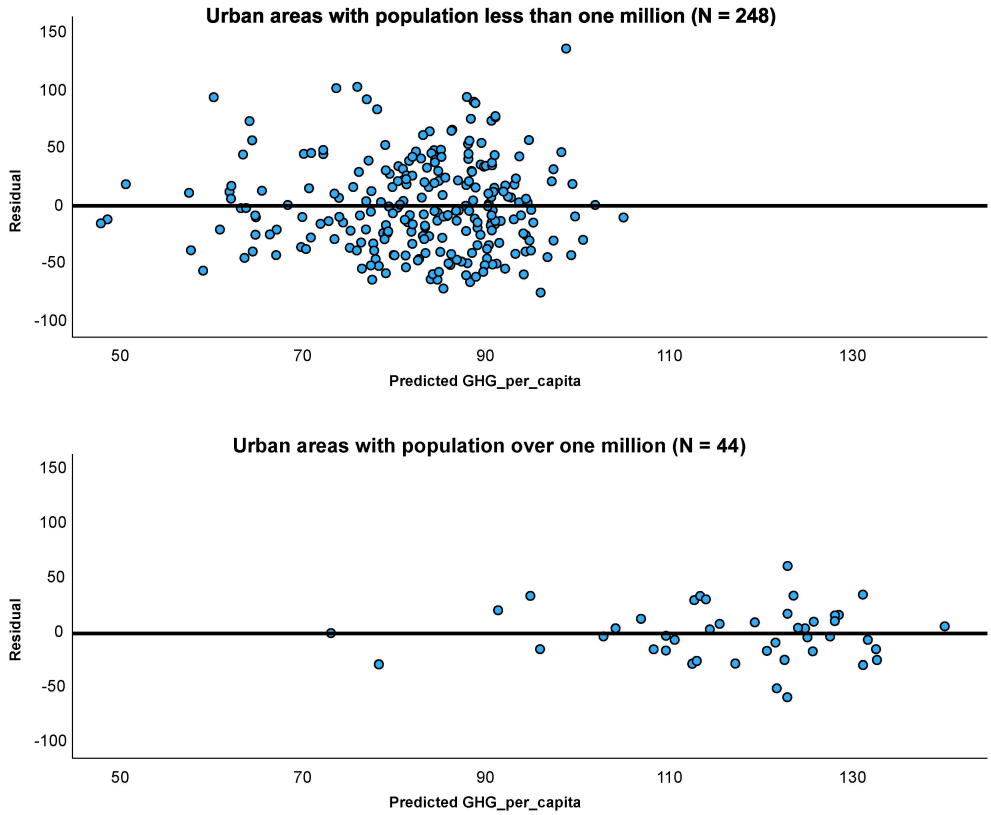

Figure 7. Regression residual scatterplots of GHG_per_capita: comparison between urban areas with population less than one million (N=248) and over one million (N=44)

Part Correlations

While the R^2 value indicated the amount of variance in *GHG_per_capita*, explained by *ln_PMT_per_capita* and *Drive2Work_pct* collectively, it did not offer insights into the unique variance with which each independent variable contributed to the overall variance in the *GHG_per_capita*. To address this limitation, part correlations between the independent variables and GHG emissions were computed and examined (Table 4, Figure 8). Specifically, the squared part correlation ($Part^2$) represented the unique variance in *GHG_per_capita*, explained by an independent variable, after removing the influence of the other one. In urban areas with populations under one million, *ln_PMT_per_capita* explained 1.03% of the variance in *GHG_per_capita*, whereas *Drive2Work_pct* accounted for 3.71%. Conversely, in urban areas with populations over one million, *ln_PMT_per_capita* explained 0.77% of the variance in *GHG_per_capita*, whereas *Drive2Work_pct* accounted for 6.37%.

Table 4. Correlations between the independent variables and GHG emissions from road transportation

	Independent Variables	Zero-order	Partial	Part	$Part^2$	
Urban areas with population less than one million (N=248)	*ln_PMT_per_capita*	−0.1529	−0.1039	−0.1013	0.0103	(1.03%)
	Drive2Work_pct	0.2242	0.1950	0.1927	0.0371	(3.71%)
Urban areas with population over one million (N=44)	*ln_PMT_per_capita*	−0.4371	−0.1013	−0.0879	0.0077	(0.77%)
	Drive2Work_pct	0.4970	0.2806	0.2524	0.0637	(6.37%)

ln_PMT_per_capita: log transformation of passenger miles travelled (PMT) per capita
Drive2Work_pct: percentage of workers who drive to work

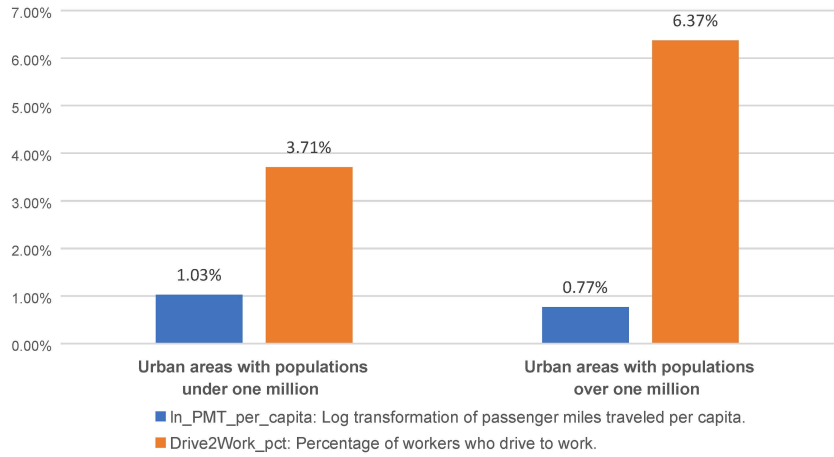

Figure 8. $Part^2$ values of ln_PMT_per_capita and Drive2Work_pct in urban areas with populations under one million and those with populations over one million

The unique influence of *ln_PMT_per_capita* on *GHG_per_capita* was assessed after removing the influence that it shared with *Drive2Work_pct*. Likewise, the unique influence of *Drive2Work_pct* on *GHG_per_capita* was evaluated after removing the influence that it shared with *ln_PMT_per_capita*. Notably, the negative correlation coefficients associated with *ln_PMT_per_capita* suggested a reductive effect on *GHG_per_capita*. In contrast, the positive correlation coefficients associated with *Drive2Work_pct* implied a contributory effect on *GHG_per_capita*.

Discussion

The findings confirm that using public transportation helps to reduce GHG emissions from road transportation in urban areas. Specifically, in urban areas with populations under one million, a 1.03% reduction in GHG emissions can be attributed to the personal miles travelled (PMT) via public transportation, while the workers who drive to work contributed 3.71% of GHG emissions. In contrast, urban areas with populations over one million observed a 0.77% reduction in GHG emissions from PMT via public transportation, but workers who drive to work contributed 6.37% of GHG emissions. Although 1.03% and 0.77% might seem minor, they are significant within the context of the U.S. transportation sector. For perspective, public transportation accounted for just 1.2% of the total person-miles travelled in 2022, whereas private vehicles dominated with 82.8% (Federal Highway Administration 2022).

This study also finds that *ln_PMT_per_capita* and *Drive2Work_pct* collectively explained more variance in *GHG_per_capita* in urban areas with populations over one million (25.47%), compared to those with populations under one million (6.05%). This suggests that, besides *ln_PMT_per_capita* and *Drive2Work_pct*, other non-commute factors—such as personal travel by private vehicles and freight transport by commercial vehicles—might have a more significant impact on GHG emissions in less populated urban areas.

In both types of urban areas, the percentage of workers who drive to work (*Drive2Work_pct*) is the most influential variable contributing to an increase in GHG emissions from road transportation. Specifically, its unique contribution is 3.71% in urban areas with populations under one million, and 6.37% in those with populations over one million. This implies a greater dependence on and use of private vehicles in large urban areas. The levels of GHG emission within an urban area depend on the locations of activity centres and where people reside (Legras and Cavailhès 2016). Hypothetically, an urban area might have a dense core with relatively lower per capita GHG emissions. However, this advantage can be negated by the surrounding suburbs, which tend to have higher per capita GHG emissions, due to greater reliance on cars and to sprawling development patterns that lead to longer and more frequent trips. This scenario might be more evident in urban areas with populations over one million.

These findings are valuable for mitigating GHG emissions in the transportation sector. On the public transportation front, investing in efficient public transportation systems and expanding public transportation networks can help reduce car dependency (Ali et al. 2021, Bleviss 2021). Improving public transportation service frequency, quality, and affordability would encourage people to use public transportation rather than driving (Ercan et al. 2016).

Beyond public transportation, several other strategies can also help mitigate GHG emissions in urban areas by reducing car-centric transportation. So, prioritising transit-oriented and mixed-use development is crucial for sustainable urban development (Crane 1996, Brownstone and Golob 2009, Cervero and Murakami 2010, Klungboonkrong et al. 2017, Ali et al. 2021). By integrating residential, commercial, and recreational spaces close to major transportation hubs, these developments reduce the distance between key destinations, such as workplaces, homes, and amenities. The proximity of such developments encourages people to use alternative modes of transportation, instead of relying on cars.

Promoting active transportation and commuting, like walking and cycling, also contributes to urban eco-friendliness. Designing pedestrian-friendly neighbourhoods, creating dedicated bike lanes, and launching bike-sharing programs (Handy et al. 2002, Cervero and Duncan 2003, Neves and Brand 2019, Tong et al. 2023, Ng et al. 2024) can make these options more viable and appealing. Telecommuting is another viable option to reduce personal vehicle use by minimising the need for daily commuting, which helps to alleviate traffic congestion and air pollution (Giovanis 2018). As more people work remotely, the number of work-related trips decreases (Choo et al. 2005), leading to less fuel consumption and to lower GHG emissions (Shabanpour et al. 2018). These initiatives help to reduce the dependence on car travel and to foster healthier and more environment-friendly communities.

Encouraging carpooling and ridesharing (Caulfield 2009, Jacobson and King 2009, Martin and Shaheen 2011, Toth 2015, Jung and Koo 2018) can be an effective strategy to improve transportation efficiency. These practices promote more efficient vehicle use, resulting in fewer cars on the road and the reduction of traffic congestion.

Implementing congestion and road pricing (Cavallaro et al. 2018, Anas 2020, Axsen and Wolinetz 2021, Veitch and Rhodes 2024) is another policy tool worthy of consideration. By attaching a cost to driving during peak times or in high-demand areas, it disincentivises unnecessary trips and it encourages commuters to shift toward alternative modes of transportation.

Transitioning from traditional fuel-powered vehicles to electric vehicles (EVs) or to those utilising cleaner energy technologies (Rabl 2002, Chan et al. 2013, Chong et al. 2014, Bleviss 2021, Chang and Huang 2022) can help to reduce GHG emissions. However, given the higher cost of EVs, government intervention is key. Incentives, such as tax credits, reduced parking and toll fees, together with access to priority

lanes (Bjerkan et al. 2016, Breetz and Salon 2018) can lower the financial barriers to EV adoption and it can accelerate the shift toward cleaner transportation technologies.

In the long term, adopting the mind sponge mechanism, a framework describing how individuals observe and process cultural and ideological values (Vuong and Napier 2015), it can be an effective approach for bolstering the utilisation of public transportation. Making public transportation more accessible, affordable, connected, and efficient takes time, but these efforts can gradually change the society's mindset about public transportation in a positive way. This, in turn, would motivate more people to use public transportation.

While this study provides further insights into the impact of public transportation on reducing GHG emissions from road transportation, it has several limitations. These limitations include both data-related and methodological issues. Although addressing these limiting factors would require additional attention and effort beyond the current study, they present opportunities for future research. The GHG emissions dataset employed in this study utilised 0.1° by 0.1° data points to capture and to record global emission tonnage. While this level of granularity is adequate for global-scale analyses, it is insufficient for research that targets smaller geographic units, such as cities or counties, where more localised details are crucial. Although the emissions data were focused specifically on the road transportation sector, it lacks the details needed to distinguish between different emission sources. Key distinctions—such as emissions by trip purpose (e.g., commuting, shopping, recreation) or between personal and commercial vehicle use—are not captured. Access to such detailed data would help to evaluate the specific impacts of transportation activities on GHG emissions.

This study centres on 292 urban areas across the U.S. that provide public transportation services. While the findings may not be directly transferable to other countries or regions, the analytical approach and methods present a framework that can be helpful for conducting similar research elsewhere. This opens up possibilities for comparative studies to explore the impact of public transportation on reducing GHG emissions in urban areas outside of the U.S. Lastly, the selection of variables in this research was partially influenced by data availability and time constraints. Future studies could be enriched by incorporating additional dimensions—such as land development patterns; land use and land cover data; and public health indicators. Including such factors would enable a more comprehensive analysis and the in-depth understanding of their associations with GHG emissions.

Conclusions

This study examined GHG emissions from road transportation in U.S. urban areas to assess the impact of public transportation on reducing GHG emissions. Regression analysis was applied to investigate how public transportation usage and commuting

to work using private vehicles affect GHG emissions in urban areas. Part correlations were examined to derive the unique amount of variance in GHG emissions that was accounted for by each variable while controlling for the influence of the other one.

The main findings indicated that public transportation usage reduces GHG emissions, although the effect is minimal. Also, commuting to work using private vehicles increases GHG emissions, which has a greater impact than public transportation usage. And both factors explained more variance in GHG emissions in urban areas with populations over one million, compared to those with populations under one million. These findings align with the existing international research, demonstrating that public transportation usage can decrease GHG emissions by 0.77% in urban areas with populations over one million, and by 1.03% in those with populations under one million. It is important to note that these findings are specific to the U.S., and caution should be exercised when applying them to other countries or regions without further research. Nonetheless, the study's methodological approach is adaptable, and it can be utilised for studying other urban areas, contributing to the existing body of literature.

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Enhancing Coastal Spatial Planning Analysis Through SAR Sentinel-1 and GIS-based Flood Hazards Model

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Abstract: This research implements GIS and SAR Sentinel-1 remote sensing data to monitor the implementation of spatial policy, especially those related to environmental planning in mitigation zones. The study focuses on the urban coastal area of Pekalongan, Central Java, Indonesia, characterized by high flood events over the last three years. The assessment tools used GIS modelling combined with data extraction from Google Earth Engine, which has accelerated capabilities in obtaining and analysing flood data using Sentinel-1 SAR remote sensing data. The evaluation results showed that GEE can model flood-affected areas with a validation level of 87%. In detail, the evaluation also showed that nine zones were allocated as settlement areas, but they are located in disaster hazard zones with a flood hazard index of 1 (high), so environmental planning policies need to be strengthened in controlling residential growth in flood disaster-prone areas.

Keywords: spatial planning; earth engine; Flood Hazards Index; SAR Sentinel-1; GIS

Introduction

The impact of urbanisation on flooding events has affected society's economy. It has also become a central issue in Asia, where geographical features and urbanisation patterns can drastically increase the number of exposed populations (Rentschler et al. 2022). Data shows that 1.81 billion people (23% of the world's population) are directly exposed to floods that occur once every 100 years (Rentschler et al. 2022). The top 10 countries in terms of the absolute number of exposed populations are the countries whose population groups are concentrated along major river systems, such as India (Nair et al. 2025), Bangladesh, Egypt, and Vietnam, or in rapidly growing coastal areas, such as Indonesia and Japan (Rentschler et al. 2022). The tendency is to develop activity centres on the coastal area that have strategic value and cause high flood risk levels (Chan et al. 2018, Sejati et al. 2023, Sejati et al. 2024). These activity

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centres' existence results from spatial planning that only prioritises strategic location and access, but it pays less attention to disaster mitigation aspects. With this phenomenon, it is necessary to evaluate the spatial planning policies so that the mitigation process can be carried out earlier and to minimise the existing risks (UNDRR 2025).

According to these data, Indonesia has entered an area affected by extensive flood disasters. Throughout 2024, there were 1,088 flood disasters in Indonesia, most of them in coastal areas (CFE-DM 2025). It is exacerbated by the area's character, which is difficult to reach during a disaster, so it requires a more effective way to respond to flood events and appropriate policymaking through zoning, according to the level of danger. The higher the level of urbanisation in areas prone to flooding, the greater the risk that will be experienced. Urbanisation and the growth of coastal cities cannot be separated from the allocation of activities in spatial planning, so there needs to be an evaluation of spatial planning as an effort to reduce the risk of flooding in the future (Sejati et al. 2023, Zaki and Jaskuła 2025).

To respond to the phenomena, an appropriate method is needed to analyse spatial planning evaluation and decision making process (Bae and Chang 2019, Feloni et al. 2020, Ishiwatari and Sasaki 2021, Pramanick et al. 2022, Sejati et al. 2025). This process can be carried out with the support of spatial analysis, which can assist in rapid mapping and it can become evaluation material for spatial planning. With this urgency, analysing the existing spatial plans to support mitigation plans in vital coastal areas is necessary (Mutaqin et al. 2024). Furthermore, priority handling zones related to community activity centres must be immediately mitigated to sustain the community's economy (Hariram et al. 2023, Faryadi 2024). This discussion continues because, in theory, disaster mitigation is still partial, so mitigation actions focus more on short-term handling that is not yet comprehensive and it has not placed spatial planning instruments in the process (Ford et al. 2022, Kim et al. 2024).

One obstacle to Indonesian spatial planning-based mitigation is the poor evaluation of spatial planning products. Government inertia in carrying the evaluation process leads to some obsolete planning products, especially when responding to flood disasters. The fragmentation of disaster data in flood-affected areas also hinders planning by complicating the evaluation process. This issue stems from data not presented spatially and based only on tabular format. Consequently, policy makers rely only on an image guided by number and losses under an unsteady spatial representation.

Since 2021, several digital map platforms and social media have initiated flood hazard zones and related data, providing the public with essential information for early anticipation. While the Indonesian government has supplemented this with open data in the form of the InaRISK website (Indonesia's National Agency for Disaster Management 2025), this information remains poorly integrated with spatial planning. It is not enough to help to analyse flood-affected areas more definitively and to provide input for evaluating the spatial plans. With this urgency, it is necessary to integrate

the spatial plan evaluation process as a form of flood disaster mitigation based on geospatial analysis. This analysis offers a more comprehensive perspective on flood-affected areas and on the position of each community activity towards flood-risk areas.

Several geospatial analysis platforms have been widely developed to support spatial evaluation analysis as a basis for disaster mitigation. Among these, Google Earth Engine (GEE) can support rapid mapping with data that can be processed via a cloud computing system (DeVries et al. 2020, Vanama et al. 2020, Uddin et al. 2021, Islam and Meng 2022, Peter et al. 2022). The platform was chosen because it has a large data capacity with various types of satellite imagery, one of which supports the use of SAR (Synthetic Aperture Radar). The use of SAR was chosen because this type of active sensor imagery supports fast mapping for flood-affected areas (Vanama et al. 2020). The advantage of SAR is that this data is not disturbed by cloud cover, so it can still capture inundation conditions in flood conditions caused by high rainfall (DeVries et al. 2020).

Studies on the use of SAR and GEE have been widely carried out (Li and Demir 2023, Zaki et al. 2023, Jodhani et al. 2024, Thomas et al. 2025). On average, using these tools only stops at extracting flood data. Various GEE and SAR data studies (Vanama et. al. 2020, Moharrami et al. 2021, Zaki et al. 2023) show that short-term inundation analysis has been successfully carried out. Vanama et al. (2020) initiated the GEE platform for monitoring, as did Moharrami et al. (2021), who utilised SAR and GEE for flood monitoring automation. Several implementations of SAR and GEE have also been carried out, such as the impact of flooding on agriculture (Li and Demir 2023, Zaki et al. 2023, Jodhani et al. 2024, Thomas et al. 2025), and the rapid mapping of floods at urban scale (Islam and Meng 2022), and globally (Tripathy and Malladi 2022, Wang et al. 2022, Li and Demir 2023, Shinde et al. 2023). These studies are interesting because the built model can indicate flood hazard zones faster with inundation height data, but it has not been maximised for spatial planning evaluation that influences the development of spatial planning-based disaster mitigation policies.

To fill the gap, this study employs the SAR and GEE models within the spatial planning evaluation process to serve as a policy-making tool for flood disaster mitigation. Developing planning policies, especially in Indonesia, is essential to create measurable research-based disaster mitigation policies with more cohorent spatial data. Furthermore, if associated with urban spatial planning analysis, this utilisation enables the evaluation of priority zones for disaster mitigation.

Methodology

Study Area

This research was conducted on the north coastal area of Central Java, with a case study in the coastal area of Pekalongan City and Regency (Figure 1), having a surface of

6,037.3 hectares. The area is inhabited by 336,709 people, with a population density of 55.44 people/hectare, mainly concentrated in the West Pekalongan Sub-district. The region's population structure tends to be expansive, characterised by a dominant productive-age population of 242,498 people, who contribute significantly to the region's socioeconomic dynamics (Buchori et al. 2022).

Figure 1. The coastal area of Pekalongan as study area

Economic activities in the Pekalongan Coastal Area depend on the physical potential of the coastal area, especially the proximity of the community to the sea as the primary resource. Fishermen, agricultural farmers, and aquaculture farmers dominate the population's livelihood. Although marine products contribute to the community's economy, the welfare level of the population still faces various challenges. The coastal area of Pekalongan has recorded an increase of 2,349 poor people, which continues to increase from year to year (Buchori et al. 2022). This is caused by several factors, one of which is the change in the environmental conditions which contribute to worsening the socio-economic conditions of the region.

Pekalongan's coastal areas face a high risk of hydrometeorological disasters. In the last three years, the frequency of floods has increased with an average of four floods per year, exacerbated by seven tidal floods (Buchori et al. 2022). This disaster has made Siwalan and Tirto sub-districts to be the most affected and vulnerable areas. This condition is caused by high rainfall and the threat of sea level rise, and it causes significant losses to the welfare of the community in the settlement. Therefore, disaster mitigation measures are needed to reduce the risk of flooding.

Earth Engine and the Un-spider Algorithm

In the event of a hydrometeorology-related disaster, optical-based satellite imagery has a very high cloud cover, making it challenging to identify flood inundation. SAR was chosen because the nature of active sensors can penetrate cloud cover, and it can be used to predict the location of inundation without being affected by the cloud cover. These advantages made us choose SAR as the data in spatial modelling.

Flood modelling uses the Google Earth Engine platform, where required data include: pre-event Sentinel-1 imagery at the time of the event; the distribution of disaster location points; delineation boundaries; and the Global Surface Water Mapping (GSWM). Both radar images were cropped based on the boundaries of the research area. After that, the pre-processing stage was carried out using the polarisation selection technique, usually called polarimetric. Modelling uses VV polarisation, considering that the results are better than those of another backscatter. The polarimetric results were then given a speckles filter to reduce the SAR data noise.

Next, the radar image was processed to obtain a model of changes before and during a flood using ratio images to become the basis for classifying flood inundation. The Sentinel-1 SAR data used was historical range data before and after the flood event. This research chose the time before it occurred, from 2021-03-25 to 2021-04-02, because historically, floods do not happen there; while the time selected after the disaster was from 2022-12-25 to 2023-01-06, because it was based on information from BNPB that Java's coastal floods in early 2023 would be the worst in the last ten years (Indonesia's National Agency for Disaster Management 2025). These results were then processed to obtain permanent water body thresholds to ensure flood and non-flood areas.

A map of tidal flood inundation distribution was produced from these several processes. The mapping results were corrected for anomalies, and the results of the inundation model on the coastal urban area of Pekalongan were obtained. The algorithm used was the UN-SPIDER algorithm (United Nations 2025). UN-SPIDER facilitates the use of space technology for disaster management and emergency response, and it refers to the algorithm model developed by the UN to assess rapid flood hazards based on synthetic radar equipment data, using SENTINEL-1A image data (United Nations 2025).

Threshold Calculation

Threshold calculation was one of the stages in tidal flood modelling, which functions to identify flood areas. This technique utilised the RI results while creating data samples based on land use classification. To make it easier to determine flood inundation, in the future, the classification will be made into two, namely water and urban areas; the formulation will be used in equation (1).

$$\sigma_{water} = \frac{\mu_{water=\frac{1}{N}\sum_{i=1}^{N} waterPOI_i}}{\sqrt{\frac{1}{N-1}\sum_{i=1}^{N} | waterPOI_i - \mu_{water} |^2}} \quad (1)$$

Where N=Number of water body samples; Mwater=Average of water body pixel values; and Σwater = Standard deviation of water body pixel values.

Evaluation of Coastal Spatial Planning Policies

This process started with modelling flood hazards to produce inundation areas based on the extraction of Sentinel 1 SAR data. Next, the results of the extraction were combined with settlement area data and overlaid. Inundated residential areas had a hazard index close to 1, while non-inundated residential areas had a hazard index close to 0. This was based on the potential losses that an area had based on flood inundation in areas of activity centres, especially within settlements (Table 1).

Table 1. Flood potential area

No	City/Regency	Sub-district Name	Inundation area (ha)	Percentage (%)	Level
1	Pekalongan City	Bendan	9.45	0	Low
2	Pekalongan City	Pasirkratonkramat	67.79	2	Low
3	Pekalongan City	Tirto	25.93	1	Low
4	Pekalongan City	Gamer	43.82	2	Low
5	Pekalongan City	Klego	18.18	1	Low
6	Pekalongan City	Poncol	25.49	1	Low
7	Pekalongan City	Bandengan	151.51	5	Moderate
8	Pekalongan City	Degayu	278.69	10	High
9	Pekalongan City	Kandang Panjang	108.13	4	Moderate
10	Pekalongan City	Krapyak	148.67	5	Moderate
11	Pekalongan City	Padukuhan Kraton	27.05	1	Low
12	Pekalongan City	Panjang Baru	29.33	1	Low
13	Pekalongan City	Panjang Wetan	23.85	1	Low
14	Pekalongan Reg.	Blacanan	129.27	5	Moderate
15	Pekalongan Reg.	Boyoteluk	67.94	2	Low

No	City/Regency	Sub-district Name	Inundation area (ha)	Percentage (%)	Level
16	Pekalongan Reg.	Depok	234.25	8	High
17	Pekalongan Reg.	Jeruksari	278.09	10	High
18	Pekalongan Reg.	Karangjompo	21.26	1	Low
19	Pekalongan Reg.	Mulyorejo	54.74	2	Low
20	Pekalongan Reg.	Pacar	9.74	0	Low
21	Pekalongan Reg.	Tegaldowo	39.67	1	Low
22	Pekalongan Reg.	Bener	14.97	1	Low
23	Pekalongan Reg.	Pekuncen	7.91	0	Low
24	Pekalongan Reg.	Api-Api	151.67	5	Moderate
25	Pekalongan Reg.	Bebel	10.13	0	Low
26	Pekalongan Reg.	Pecakaran	230.15	8	High
27	Pekalongan Reg.	Pesanggrahan	17.17	1	Low
28	Pekalongan Reg.	Rowoyoso	48.59	2	Low
29	Pekalongan Reg.	Semut	196.74	7	High
30	Pekalongan Reg.	Sijambe	7.29	0	Low
31	Pekalongan Reg.	Tratebang	92.87	3	Low
32	Pekalongan Reg.	Werdi	15.56	1	Low
33	Pekalongan Reg.	Wonokertokulon	194.46	7	High
34	Pekalongan Reg.	Wonokertowetan	0.42	0	Low
	Potential flooded area		**2,780.77**	**100**	

Potential flood areas were determined based on the ratio of the area inundated to the settlement area of each sub-district. The greater the proportion of settlements affected by inundation, the higher the level of disaster hazard, so that the area was categorised with a higher level of flood potential. To assess the flood potential level of an area, a classification was carried out, which was divided into three categories: (1) low level, with a percentage of inundated areas between 1-3% of the subdistrict area; (2) medium level, with a percentage of inundation of 4-6% of the subdistrict area; and (3) high level, if more than 7% of the subdistrict area was inundated.

The inundation results and danger zones extracted from SAR Sentinel 1 data were combined with the land use plan data (Figure 2). The comparison results produced evaluation zones which needed to be prioritised for handling. These results were formulated into recommendations for the affected areas where control instruments must be immediately prepared. Furthermore, to sharpen the evaluation, a hazard index classification was carried out from 0-1; the closer it was to 1, the higher the danger value. This value was obtained from the overlay results between the flood data extraction from GEE, and the existing and planned settlement conditions. The more danger of floods inundating the residential areas and the settlement plans, the higher the index or closer to 1.

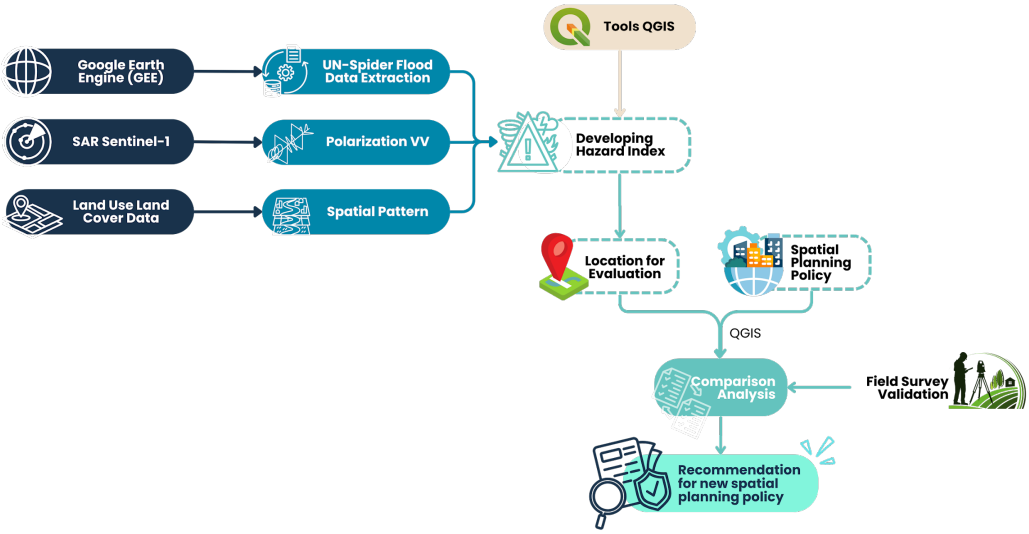

Figure 2. Analysis flow

The potential flood inundation model was built using the GEE platform with language code provided by UN-SPIDER. Next, modifications to the language code were carried out to adapt to the existing conditions so that the maximum inundation results could be extracted. The database used was Sentinel-1 SAR. In the previous explanation, Sentinel-1 imagery was included in the type of imagery with active sensors capable of recording data every six days. It was the basis for using SAR data to identify potential tidal flood inundation boundaries in the Pekalongan Coastal Urban Area.

In data extraction, polarisation was an essential process in flood identification. The type of polarisation influenced the results of the extracted inundation model. This analysis used the VV polarisation type because the results obtained aligned with the existing conditions based on the comparison results with the VH polarisation. When identifying floods using SAR, it is also recommended to use VV for coastal locations.

The following analysis determined the image threshold, before and after the flood. The assumption used as a reference was that the threshold size depended on the level of the research locus. The greater the threshold, the greater the inundation area. From the results of determining the threshold, research on the Urban Coastal area of Pekalongan used a threshold of '1.35', because the results were more appropriate to the study area.

GEE provided many water body datasets and research case studies on the Pekalongan Coastal Area using HYDROSHED V3. This water body was used to choose the 'seasonality' type of the water body classification. The slope level needed to be considered in determining the potential for inundation. There was an exception for slopes of

more than 5% as potential inundation areas due to flooding, because flooding did not impact high areas (Figure 3).

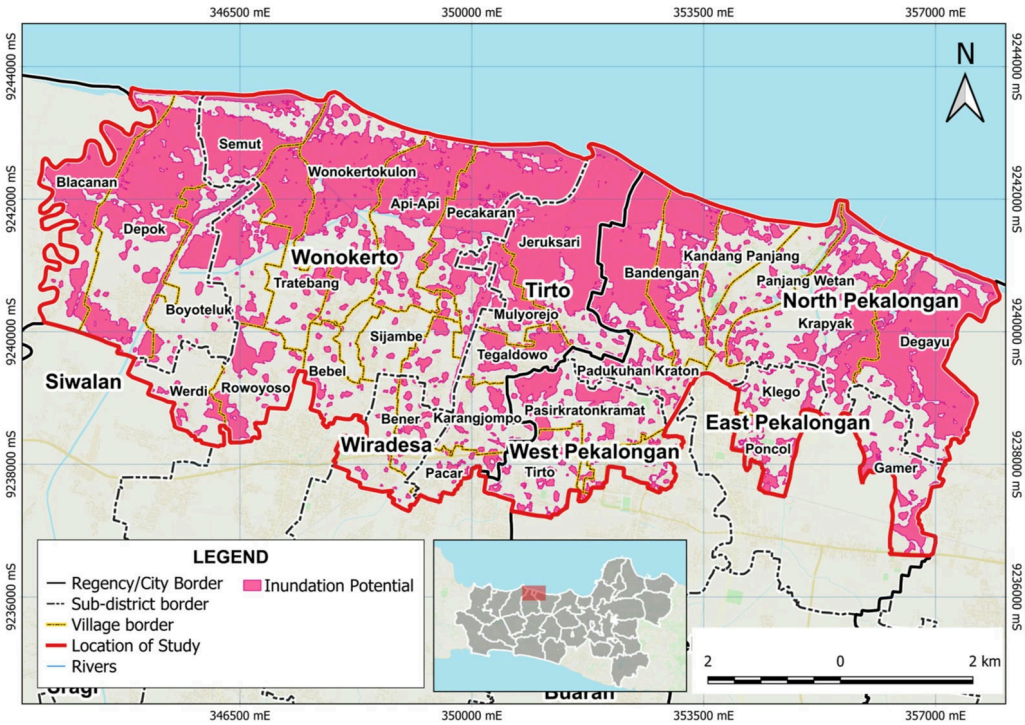

Figure 3. Potential inundation area model of urban coastal area of Pekalongan

Results

Flood Extraction Data and GIS Modelling

This process produced a potential inundation area of 2,780 hectares. To sharpen the model results, researchers validated them with field surveys and surveys via online news. Based on the results of the inundation model obtained, the most extensive tidal disaster occurred in Degayu Village, covering 278 hectares. Specifically, the following was the extent of the tidal flood inundation on the Pekalongan Coastal area using GEE.

To strengthen and to validate the results of the created model, we conducted a field survey to test the accuracy of the inundation model using stratified sampling (Figure 4). Regarding the field conditions, tidal floods inundated the entire village according to the inundation model.

The giant puddle covered only eight of the 123 points taken. Floods inundated densely populated areas, facilities, and infrastructures, such as road networks, mar-

kets, educational facilities, bridges, and ponds. Infrastructure flooding, such as road networks, would undoubtedly hamper community activities. Rob inundated the leading road network, namely Jeruksari and Tegaldowo, which were alternative roads to the primary access to the north coast of Central Java.

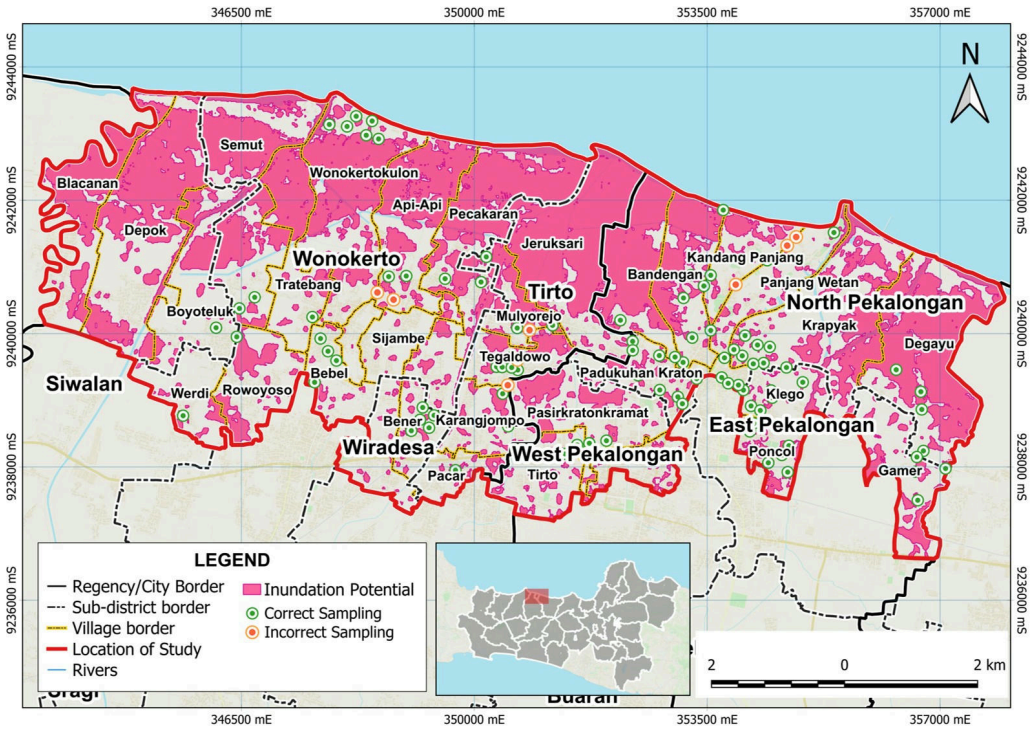

Figure 4. Sample points for validation of flood-affected locations

The road network in several Wonokerto sub-districts also experienced flooding at several points (Figure 5). The road connecting the boundaries of Api-Api and Pecakaran villages was flooded to a depth as high as 20 cm. The cause of flooding entering the road network in Wonokerto District was the road's proximity to ponds, which were only approximately 150 cm deep.

The road in the same direction as the Wonokerto River, which borders three sub-districts of Pekalongan Regency (namely Wiradesa, Wonokerto, and Tirto), also experienced flood waters as high as approximately 40 cm. This area inundated the road network, and residential areas also experienced flooding. The proximity of the ponds, the lack of well-maintained drainage, and the community's decision to stay were factors in the occurrence of floodwaters in the area.

Several preventive efforts have been carried out, and they were structurally visible to both the government and the society. In the northern part of North Pekalongan

District, the government has built a 3-meter-high embankment, as a form of structural mitigation. Water pumps were continuously active at several points, such as the Kusuma Bangsa Pump Station, and the Merican Pump Station (Figure 6).

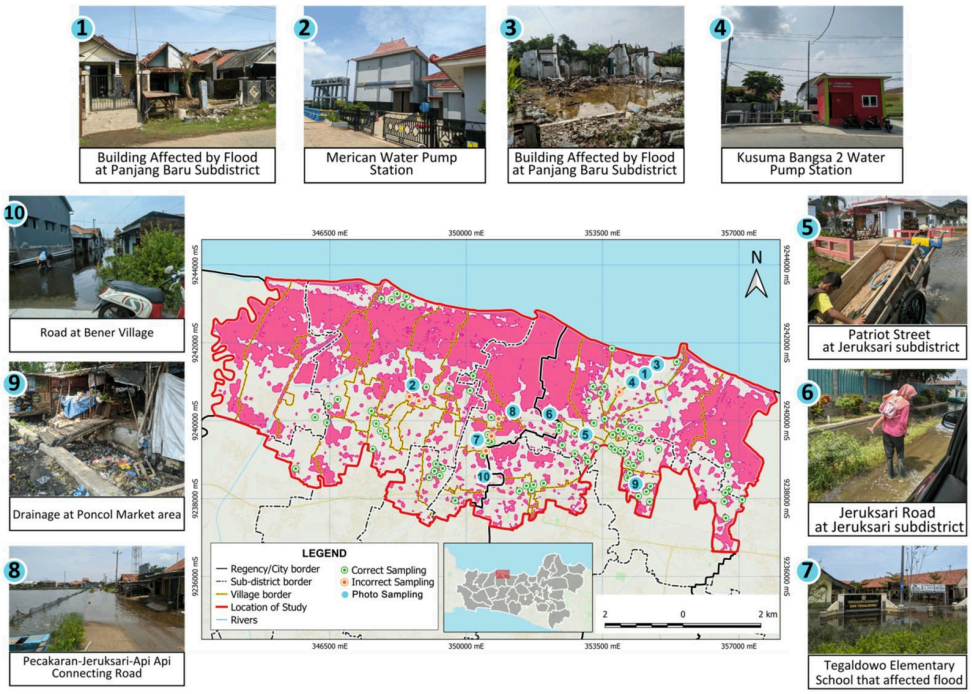

Figure 5. Residential areas in high-hazard level

Figure 6. Pump station for preventive measures against the impact of flooding

The inundation model only provided extraction, therefore, the role of DEM data in the next model had to be used to determine the depth of the inundation. The results of the depth model were then carried out by the Fuzzy Membership, which ultimately produced a tidal flood hazard index on the Pekalongan Coastal Area. The index prepa-

ration referred to the Technical Module for Flood Disaster Risk Assessment. From the results of the index analysis, the danger value for the Pekalongan Coastal Area was obtained (Figure 7), where the higher the value (close to 1), the higher the vulnerability of the coastal area.

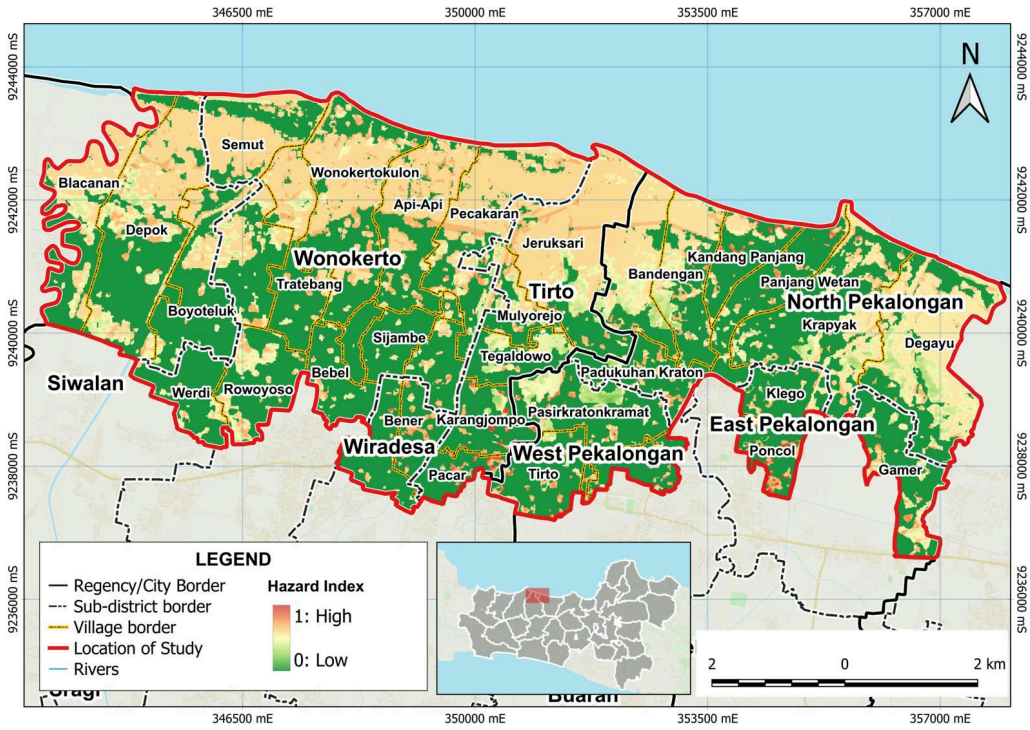

Figure 7. Hazard Index for the Pekalongan Coastal Area

UN-Spider provided a language code to determine the size of the affected residential and agricultural areas. Based on the overlay results with inundation, it was found that the settlement area was 191.15 hectares, and the cropland area was 134.62 hectares. The following was a breakdown of the area of inundation based on the affected land cover (Table 2).

Table 2. Hazard area by land use

Flooded Area	Area (ha)	Percentage (%)
Settlement	191.15	7
Cropland	134.62	5
Potential flood area	2,382.93	88
Total	2,708.70	100

Coastal Spatial Planning Monitoring and Evaluation

The evaluation was carried out by utilising spatial planning policy data from the government and risk model results. The evaluation of the plan was carried out to measure whether the spatial planning has considered disaster aspects in planning in the form of the Pekalongan Regency/City Spatial Policy. The following map compared the model with the spatial plan and the Built-up Settlement Growth on the Pekalongan Coastal Area (Figure 8, Figure 9).

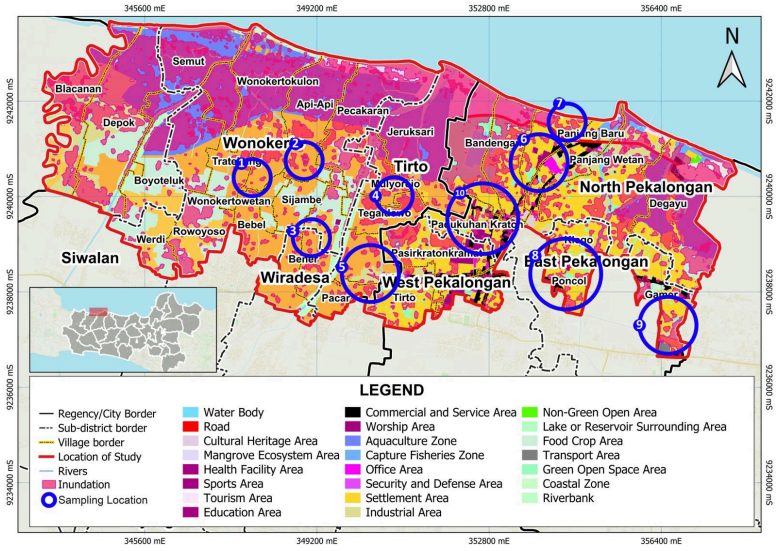

Figure 8. Overlay comparison between the Hazard index to the Spatial Planning Policy map

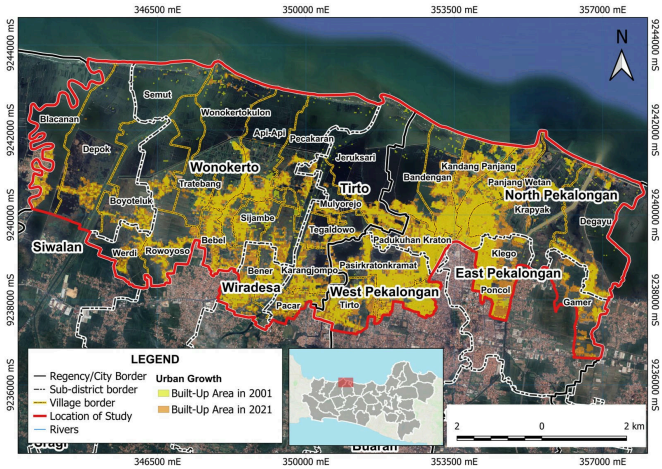

Figure 9. Built-up growth in hazardous areas

Based on the sampling model for tidal flood risk prediction, which had a medium to high range, it was found that almost every spatial pattern class with indications of high activity had a very high-risk class for tidal floods. Sample 1 was Tratebag Village, with a spatial pattern class designated for urban residential areas, fish farming areas, and food crop areas affected by high risk, especially in the urban residential area class. Sample 2 (Api-Api Village) had similarities with Tratebag Village, where the spatial pattern of urban residential areas can potentially be affected by very high risks. The spatial pattern for industrial use had also the potential to be affected by risk, as in sample 5, which is Karangjompo village.

When supposed to analyse the administrative side of Pekalongan City from all taken samples, it was found that the spatial patterns designated both for high activity (such as residential areas, trade and service areas, public facility areas), and for limited production (as forest areas), were affected by moderate risk to hazardous classes.

Looking at this comparison, the preparation of spatial planning for the Pekalongan Coastal Area had yet to make the disaster component a primary aspect of planning. Disasters were an essential component in preparing a plan which concerns human life. Returning to the discussion regarding the planning connectivity with disasters, the role of spatial data, such as optimising open access data, could not be denied. It was crucial when it was related to disasters. The level of accuracy of data will have implications for increasing the people's sense of security because detailed data results will influence an analysis, which, in this case, was on the disaster risk. Cloud computing was one answer to the efforts to optimise this issue. The Pekalongan Coastal Area, as a locus that has been tested and analysed for risk levels using cloud computing, could collect data and analyse it quickly. The results obtained were also appropriate based on the results of model tests by going directly to the field.

Discussion

The growth and development of geospatial information technology is now increasingly advanced, especially in remote sensing-based disaster analysis. Platforms which utilise cloud computing dominate various spatial analyses in multiple contexts. This study showed that Google Earth Engine captures the phenomenon of changes on the earth's surface. For the North Coast of Central Java, especially the Pekalongan Coastal Area, spatial planning policymakers should open their mind so that planning outcomes could respond to these problems, not the opposite. Complex issues related to disasters in coastal areas require a tool which is always up to date to monitor the actual conditions. Therefore, these findings relating to optimising data for disaster risk assessment were proven to be easy to use and they can be a tool to help prepare the planning components. The development of this tool provides benefits in the world of spatial planning,

especially urban planning, which is closely related to flood events (DeVries et al. 2020, Vanama et al. 2020).

A rapid response to flood disasters is needed to get better solutions. Responses can be interventions to pre-disaster, disaster, and post-disaster conditions. Often, in Indonesia, the biggest form of intervention is post-disaster, where mitigation is carried out only based on certain spots and it is short-term. According to the theory of Prasad (2020), the form of mitigation must start with planning; in this case, spatial planning becomes an instrument for pre-disaster intervention. This condition must undoubtedly be supported by tools that can elaborate between disaster data and the need for faster analysis. Based on this theory, the existence of GEE is beneficial, especially in the rapid response to spatial evaluation, so that mitigation planning can be carried out earlier based on the results of the spatial plan evaluation.

Furthermore, the Sentinel-1 SAR data used in the GEE and GIS models are real-time and they are not influenced by the cloud cover, making them suitable for rapidly mapping flood events. It is an advantage because GEE can combine flood phenomena with social data, meaning that the estimates of the population exposed to flood risk can be known earlier (Li and Demir 2023, Zaki et al. 2023, Jodhani et al. 2024, Thomas et al. 2025). This is in line with the principle of disaster response, which states that analysing the populations requiring mitigation is essential in reducing disaster risk. That is related to the fact that current urban problems are closely related to anthropogenic activities, with the primary subject being the population. Whether intentional or not, community activities impacting coastal environmental changes can trigger disasters.

Several facts are revealed in this research. First, the development of geographic information technology now supports rapid mapping activities. Rapid mapping is needed to accelerate policymaking, especially in assessing or viewing emerging disaster risks as part of the prioritisation of management and disaster mitigation plans integrated with spatial and urban planning. One of the functions and benefits of rapid mapping is that it can help the government and the community to understand and to recognise the areas affected by disasters more quickly. And it helps to determine handling priorities, which can be used as a reference for technical matters, such as physical and non-physical assistance and handling.

However, a fundamental problem often experienced in the modelling world is how spatial data is presented by various platforms, especially by Google Earth Engine. The Google Earth Engine platform has several advantages; one is that it helps to execute mathematical algorithms quickly and it can manage, display, and analyse data rapidly and systematically. However, the data obtained through the Google Earth Engine platform still has some things which need to be improved, especially in terms of data resolution. Data resolution is one of the crucial things that needs to be considered to avoid bias, especially in the decision-making process. This aligns with the thoughts of Tripathy and Malladi (2022), and of Song and Hu (2022), who suggested the need for

a rapid disaster management process based on reliable spatial data. But, as the GEE platform is free, high-resolution data is not available.

The second fact is the validation process. In some literature (Li and Demir 2023, Zaki et al. 2023, Jodhani et al. 2024, Thomas et al. 2025), the GEE model results must be validated in the field. Validation results have been conducted where the algorithms used by cloud computing can form the basis of the analysis. One such study focused on the algorithm developed by UN-SPIDER. The results showed that the validation process has reached 87% of the valid locations in the model. This addresses the research challenges of various GEE users in utilising GEE for flood inundation modelling.

This step was taken due to the lack of innovation in spatial planning, which still relies on post-disaster data, and it is not up to date. Although the validation rate of this model is only 87%, it can be used to respond to the theory of rapid flood response. Furthermore, the theory of spatial open data has also begun to develop, as stated by da Silva et al. (2020), and by Jumadi et al. (2024), where the public needs to visualise a flood disaster phenomenon to facilitate decision-making. In this case, by public policy theory regarding disaster and analysis for regional and urban spatial planning, a decision on emergency conditions needs to be prioritised for public safety (Joshi and Aoki 2014). With this research, the decision to control space utilisation in zones with a level of danger, and with a hazard index close to 1, can be made immediately.

In the algorithm model developed by UN-SPIDER, we can easily extract inundation data at specific times during the duration of the flood. This data can be combined with spatial data and settlement distribution data to prioritise handling areas at risk of flooding. If this can be well implemented, it can speed up the decision-making process. The decision-making process requires a tool that can help to measure decision-making accuracy (Pramanick et al. 2022). It was proven by the effectiveness of the algorithm developed by UN-SPIDER in Google Earth Engine that, in less than an hour, flood inundation data and flood-affected areas can be analysed to support disaster mitigation planning, especially in determining priority handling zones.

This model can help policymakers to prepare a policy brief that can be executed as a quick response when a flood disaster occurs (Sejati et al. 2024). In addition, the benefit of this research is how data extracted through cloud computing platforms, especially Google Earth Engine, can become reference data. This means that the data obtained on the cloud computing platform does not need to be downloaded, which makes data utilisation more practical. Thus, mapping and spatial analysis do not need to go through a long pre-process, but it can be executed efficiently using a cloud computing platform. However, despite the benefits that make the spatial mapping process more manageable, it needs to be emphasised that cloud computing platforms still need to be further developed, especially in data validation and accuracy.

Furthermore, Pekalongan Regency and Pekalongan City are world heritage areas. This refers to the condition of this city, which is the largest batik industry city that

UNESCO has confirmed. However, it is known that both towns are vulnerable to sinking. It is predicted that, by 2050, Pekalongan City will sink faster than other areas, due to land subsidence issues (Buchori et al. 2022). A planning map should be accurate to avoid the readers' misunderstandings and to be able to depict what is happening on the ground. We can see additional benefits too, especially regarding strategic planning within a specific period (Tingsanchali 2012).

With this concept of rapid mapping, some things need to be corrected when they become criticisms of inappropriate development. Various fundamental things must be addressed immediately, especially in improving the environment, which worsens over time. This can be seen from the nine zones on the spatial plan map that are allocated as residential areas but are affected by flooding with a high level of hazard. That is further exacerbated by a development concept based on something other than disaster mitigation and climate change. Runoff flooding and rising sea levels are known to worsen the environmental conditions in Pekalongan City and Pekalongan Regency (Buchori et al. 2022).

Some areas have collapsed and they can no longer be utilised for community activities. The results of this research should be used as a reference in licensing and managing disaster-prone areas and in disaster management plans to reduce perceived disaster risks. Finally, the results of this research need to be responded to immediately by the government and the community to formulate spatial policies at the regional and national levels related to flood disaster mitigation based on spatial policies.

Some of the weaknesses of this research are the moderate scale of spatial data and planning. Furthermore, to improve the performance of the analysis results, spatial data with better resolution and scale can be used. This is important in order to provide a more detailed evaluation of priority areas for flood management, especially areas affected by high levels of hazard. Thus, management recommendations can be more accurate and specific.

Conclusions

GEE can extract flood data with calculations supported by the UN-SPIDER code, and it can answer the need for rapid mapping to respond quickly to flood management policies. The locations produced by the model did indeed experience flooding with impacts that disrupted community activities and caused some damage to facilities. The flood model used to evaluate the spatial planning can show evaluation results where there are the danger zones.

These findings should be input for evaluating spatial planning policies because dangerous zones should not be allocated for settlements. Furthermore, this research needs to be continued to accommodate more detailed risk calculations with various

other input variables, so there is a need to combine models from GEE with other spatial models to strengthen the analysis of disasters and their impacts.

Further research can be conducted by adding several analytical factors, such as the economic and social impacts of the results of this evaluation model. This is important because spatial planning is closely related to the planning of economic and social activities of the community. Therefore, the results of this study can provide benefits for the economic and social sectors in coastal urban areas.

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Tourism sustainability and local governance challenges in a protected mountain area

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Abstract: Since the COVID-19 pandemic, protected areas in mountain regions have become increasingly popular tourist destinations. However, mountains are considered fragile in terms of natural and cultural heritage, so a balanced use of resources is needed to develop tourism with long-term benefits for the local communities. Through multi-stage research, the present study investigates the perspective of accommodation providers on sustainable tourism in the Serras D'Aire and Candeeiros Natural Park (PNSAC), Portugal. Data reported on Booking.com was considered, in terms of tourism operators' commitment to predefined sustainability practices. Then, the tourist accommodations were analysed by proposing a ranking through an integrative approach. Additionally, in-depth semi-structured interviews were conducted to gain better understanding on the journey of accommodation providers towards sustainable tourism, in relation with the PNSAC administration. The results emphasised that only 33.3% of accommodation providers claimed sustainability practices, with 40% categorised as 'inadequate' in the rankings, as they implement only a few measures. Given the identified weak interaction between tourism providers and the PNSAC authority, there is a need for collaboration to promote sustainable tourism, preserve natural resources, and support regional development.

Keywords: mountain region; protected area; sustainable tourism; Booking.com; tourism accommodation

Introduction

Tourism is still an ever-growing economic sector, as the tourism industry managed to recover 63% of pre-pandemic levels in 2022 alone (UNWTO 2023). Outpacing the global economy in times of conflict and with a hoovering economic crisis, Europe is still the leading destination, registering 585 million arrivals in 2022 (UNWTO 2022). The dramatic halt observed during the COVID-19 pandemic, largely suppressed by the so-

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called proximity of tourism's growing demand for open-air and nature-based tourism activities, seems like a thing of the past.

However, most market reports from 2019 already award nature-related tourism as a booming sector, further emphasised by the pandemic aftereffects on people (Lebrun et al. 2021, Jafari et al. 2023, Silva et al. 2024). Booking.com stated that over 76% of global tourists were determined to travel sustainably (Booking Holdings 2024) – a growth of 15% over the results of 2021; other data, too, confirmed that 81% of tourists mentioned sustainable travel as an important aspect of their travel choices (Rincon et al. 2021).

The importance of natural habitats is paramount for nature-based tourism supply, where Natural Protected Areas (NPAs) are prime candidates, despite restrictions regarding tourism typology and intensification (Mancini et al. 2022). This creates a tension between two approaches. On the one side, tourism enthusiasts advocate for the sustainable use of natural areas or even conservation tourism (Eagles et al. 2002, Page 2005, Fredman et al. 2012, Padma et al. 2022, Trišić et al. 2022). On the other side, conservationists encourage zero tourism movements (Pikkemaat et al. 2019, Milano and Koens 2022, D'Souza et al. 2023, Hehir et al. 2023). Anthropogenic pressures are known to influence natural ecosystems worldwide, while land-use (Gaglio et al. 2019, Buongiorno and Intini 2021, IUCN 2024), soil erosion (Dubost 1997), water pollution (Baptista and Santos 2016), and climate change (Gössling and Hall 2006, Tito et al. 2020, Tofan and Niţă 2021) are some of the most studied human impacts. Though we rely on NPAs to achieve sustainability, many of these areas offer weak protection against human activities (Leverington et al. 2010, Watson et al. 2014).

While the overarching principles of sustainable tourism are well-established, their practical application within the specific context of NPAs presents a unique set of challenges and opportunities that warrant more detailed examination. Research into effective NPA management strategies went beyond general theory to explore concrete, location-specific approaches. For example, the success of the eco-tourism model of Socio-Ecological Systems in Costa Rica's Biological Preserve highlighted the importance of balancing the visitor numbers with the ecological capacity through a collaborative, multi-stakeholder governance structure (Miller et al. 2023). Similarly, Snyman and Bricker (2019), with examples from all over the globe, stated that carefully designed tourism can contribute to conservation efforts and it can generate revenue for the local communities while addressing several mechanisms to mitigate human-wildlife conflict. In another context, the management of National Parks in Australia, New Zealand, Canada, and the United States offered insights into maintaining strict conservation policies while still providing controlled access for educational and recreational purposes, demonstrating that a "zero tourism" approach isn't the only way to protect fragile ecosystems (Ferretti-Gallon et al. 2021). These case studies illustrated the need for tailored, adaptive management plans that consider the unique environmental, social, and economic dynamics of each protected area. In this context, it is

considered that proper sustainable tourism practices are essential to achieve sustainable development (Buongiorno and Intini 2021).

Mountains were among the first to receive visitors, leading to infrastructure improvements, jobs and business creation, and an opening to the outside world. Tourism is perceived as an activity that can generate development opportunities and revenues for local people, especially in sparsely populated mountain areas, promoting social inclusion (FAO and UNWTO 2023), and preserving local traditions and practices (Romeo et al. 2021). In this sense, the success achieved by tourism in numerous regions over decades has fueled hopes and expectations for mountain regions worldwide. This interest has evolved from a primarily focus on Western tourists to a demand from domestic tourists, both being increasingly interested in mountains assets (Debarbieux et al. 2014). In this regard, FAO (2022) estimated that mountains account for about 15-20% of world tourism.

The importance of mountains to the planet and humans alike is beyond the obvious natural resources of these regions, if considered that 26% of the planet's population lives either within or near mountain areas (Martín-López et al. 2019, Glushkova et al. 2023), and that they represent 24% of the global land surface – so, mountain areas are of the uttermost importance to humankind (Wyss et al. 2022).

The remoteness and harshness of the mountain environment, along with the ancestral occupation that was mostly concerned with exploring the natural resources, without worrying about their responsible use, led most of these regions to be under some sort of a legal natural protection status, representing nowadays 32% of global designated protected areas (Egan and Price 2017). In many ways, the legal protection status preserves the natural setting, thus serving as an impediment to the development of established communities, and leading, in some cases, to precarious livelihoods.

Still, Butzmann and Job (2016) outlined that, in addition to the main purpose of protecting the natural patrimony, protected areas must also fulfil the role of "use" for tourism and recreation. UNWTO (2018) emphasised that for local communities to benefit, in the long term, from the inputs of tourism development in mountain destinations, this must be done simultaneously with the preservation of natural resources and their sustainable use. Therefore, proper development plans should be developed and sustainable tourism strategies and practices (Canteiro et al. 2018, Bergantino et al. 2021, Buongiorno and Intini 2021, Dragan et al. 2024) should be implemented, leading to the sustainable development of mountain regions.

Since the 1980s, there has been an increasing focus on integrating sustainability into the tourism industry (Saarinen 2021). Sustainable tourism considers tourism's economic, social, and environmental impacts, while meeting the needs of visitors, the industry, and the local communities (UNEP and UNWTO 2005). The aim is to minimise the potential adverse effects of tourism and to maximise the positive impacts (Dias et al. 2026). This is especially important in NPAs, which focus on preserving biodiversity

while providing educational and recreational opportunities. Successful sustainable tourism often involves collaborating with the local communities to align tourism development with their economic interests and to preserve the cultural heritage (Ianos et al. 2012, Tulla et al. 2017, Bennett et al. 2018, Nguyen and Jones 2022).

A trend in rural tourism in Portugal is to localise new accommodation units closer to or within protected natural areas (Bento et al. 2022). Tourism in protected areas has become a national target, especially in the last two decades (Martins 2022). According to the National Tourism Strategy 2027, one of the ten strategic designated actions is "Nature", promoting tourism in NPAs to convey economic value and its further integration into NPAs management objectives (Tourismo de Portugal 2017). The post-pandemic growing interest in NPA tourism (Lebrun et al. 2021), the stakeholder perspective (Renfors 2021, Sørensen and Grindsted 2021), and the enacting strategies to develop the activity in a sustainable way (Buongiorno and Intini 2021) are even more complex topics which still require further research.

Lately, access to remote natural places from mountain regions has been facilitated by online platforms with consumer-centric tech features, which tourists use to make accommodation decisions and local travelling arrangements (Liu et al. 2020). The technological development of online tourism platforms offers both stakeholders and consumers supply mechanisms for the development of tourist accommodation facilities and activities inside NPAs, enabling local development (Lam et al. 2020).

Numerous studies have analysed information from online platforms to explore the characteristics of accommodation units in specific locations (Abdirazakov et al. 2023), or to examine specific aspects, such as room pricing and policies (Oses et al. 2016, Sánchez-Lozano et al. 2020, Santos et al. 2021), or hotel scores system (Mellinas and Martin-Fuentes 2021, Leoni and Boto-García 2023). Other research utilised metadata to examine tourists' perceptions on various issues, including environmental concerns and practices based on individual reviews (Foris et al. 2020, Mariani and Borghi 2023).

Still, sustainability practices proposed on online platforms are rarely examined (Arzoumanidis et al. 2022), particularly regarding their utility in analyzing their adoption in a certain area (Rutecka et al. 2025) and assessing progress toward achieving sustainable tourism. Recent scholarly approaches have addressed the challenges of communicating these sustainability practices (Tölkes 2018, Bogren and Sörensson 2021, Borges-Tiago et al. 2021) and the need to investigate the engagement of accommodation providers (Mota et al. 2024, Rutecka et al. 2025), especially given the high resource consumption and potential adverse environmental impacts of the tourism industry (Melissen et al. 2016, Reem et al. 2022).

Another way of communicating the sustainable tourism commitment is on the accommodation units' websites (Hsieh et al. 2012). However, the results of studies focused on different places highlighted that only a small share of the hotels use this alternative (Khatter et al. 2019, Pato and Duque 2021), and often in a superficial way (Santos et

al. 2019). At the same time, there is no standard format, and they typically disseminate the information which they consider relevant through a sectorial approach (Bogren and Sörensson 2021).

Online platforms have the advantage of containing a large amount of data on the same sustainability practices and they can be used for comparative and correlative analysis. However, Tölkes et al. (2018) emphasised that there is still a limited understanding of communicating sustainability in tourism, an issue that research needs to address further. Moreover, recent studies emphasised the need for comparable data to monitor the impacts (environmental, economic, social) of tourism in mountain areas, in order to better inform planning decisions and to promote sustainable practices for the benefit of local communities (Romeo et al. 2021, FAO 2022, FAO and UNWTO 2023).

Given this research background, the current study aims to address this gap by focusing on the claims made by accommodation providers regarding their sustainability practices on the Booking.com platform, in a distinct type of territory: a protected area which necessitates a balance between conservation and tourism development. Consequently, using a place-based exploratory approach, a ranking tool was developed to provide an integrative and replicable framework for other contexts. Furthermore, the study examines whether the local context fosters sustainable behaviour among tourist accommodations, also considering the interaction with the protected area administration as a promoter for the sustainable development of the mountain region.

Focusing on the Serras D'Aire and Candeeiros Natural Park (PNSAC) in Portugal, we developed a multi-stage methodology designed to: 1) investigate the accommodations which claim to implement sustainability practices, by analysing Booking.com; 2) propose a simplified approach to integratively assess the sustainability practices of accommodation businesses; and 3) explore the stakeholders' perception on sustainable tourism, considering the embeddedness of their business in a specific environment and the liaison with the protected area authority. These outcomes contribute to raising awareness on the importance of tourism providers' implementing and communicating sustainability practices. It also provides valuable insights for various stakeholders regarding the particular situation of protected areas and the sustainable development of mountain regions. In addition, the proposed tool point out the need for an integrated approach to support the accommodation providers' commitment to apply sustainability practices and, thereby, to promote sustainable tourism.

Methodology

Study area

The Serras D'Aire and Candeeiros is located in the central-western part of Portugal (Figure 1), approximately 100 kilometres north of Lisbon, and it is part of the

Estremadura Limestone Massif and the Montejunto-Estrela Mountain system. The Serra de Aires e Candeeiros Natural Park is one of 13 natural parks in the country. It was designated in 1979 through Decree-Law, and its approved regulations have been implemented by the Management Plan since 1988 (ICNF 2024a).

Figure 1. Geographic location of the Serras D'Aire and Candeeiros Natural Park

The natural park covers approximately 38,392.91 hectares and it encompasses a significant part of Portugal's most important limestone formation (PNSAC 2024). This area

spans territories in seven municipalities: Alcobaça, Porto de Mós, Alcanena, Rio Maior, Santarém, Torres Novas, and Ourém (Carvalhinho et al. 2015).

The analysis of population density for PNSAC, at the level of the last census year (2021), showed some differences (Statistics Portugal 2024). Some parishes have fewer than 50 inhabitants/km², while others have clusters of more than 150 inhabitants/km² (Figure 2). This discrepancy is particularly evident between the flatter areas surrounding the Estremadura Limestone Massif, which offer better access to arable land and water, compared to the higher altitude parishes. The latter tend to have more rudimentary access, with shallow soil and limited or no water sources.

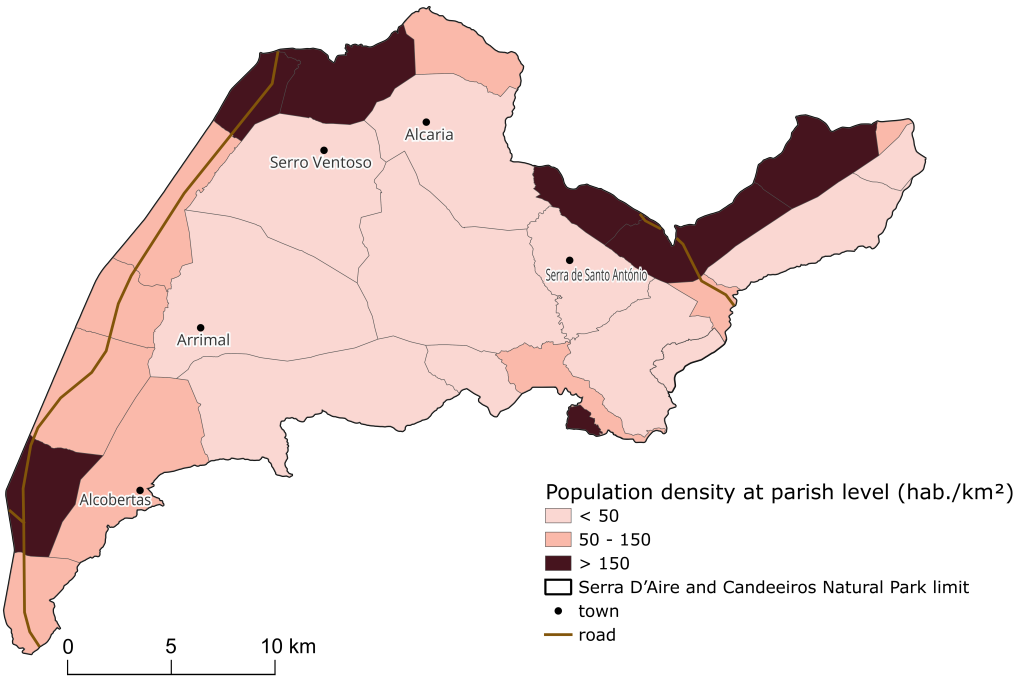

Figure 2. Population density at the parish level. Data source: Statistics Portugal (2024)

The park's outer boundaries are characterised by good road accessibility, abundant water supply, and fertile land. This densely populated and industrialised area starkly contrasts the rough terrain and the limited surface water in the PNSAC's higher-altitude landscape. Since the NPA creation, the peripheral clusters have increased significantly in size, built area, and inhabitants, while the population density in the interior of the massif has declined (PNSAC 2024). Despite the limited and the low-quality arable agricultural land, small clusters in the central area of the Plateau of St. António, which provides favourable conditions for raising cattle and growing olive groves, continue to thrive and are also favoured by tourism.

The continuous increase in the resident and active population in parishes located on the outer periphery is simultaneous due to the rise of transforming industries and services, mainly in the 1980/90 decades (PNSAC 2024), associated with the ornamental stone extraction and the constructive industry demand.

Settlements from the central areas of the NPA are strongly characterised by an ageing population, low birth rate, and emigration, especially to more industrialised areas outside the park (Statistics Portugal 2024).

In recent years, tourism has seen the highest growth among economic activities, and, in this context, the PNSAC management plan emphasised sustainable tourism management as a priority (PNSAC 2024). Moreover, ICNF (2024b) analysed the total number of visitors to protected areas in Portugal, over the period 2013-2023, and found that PNSAC ranked the fifth. In this regard, increasing pressure exists to create infrastructure and services considered insufficient for the growing demand (PNSAC 2024). The attractiveness of natural and cultural resources, combined with the increasing offer of accommodation and other services in picturesque villages, is expected to enhance the development of the tourism sector in the future; therefore, implementing sustainability practices is essential.

Tourism sustainability assessment

In the preliminary stage of research, several online tourist platforms—such as: www.greenstays.pt, www.inature.com, www.bookitgreen.com, www.tripadvisor.com, www.airbnb.com, and www.booking.com—were investigated to identify the most comprehensive set of data regarding sustainability practices necessary to carry out the study. In the end, Booking.com was selected, as it offers the most detailed insights on the tourist accommodation reporting sustainability measures.

In the first stage of the research, a sample of tourist accommodations was selected using data from Booking.com. The selection process took place in January 2023, beginning with a review of all PNSAC lodging options, which included 30 tourist facilities. The extraction of tourist accommodation units was performed manually, through a GIS-based overlay procedure, overlapping the official administrative limits of PNSAC with the spatial distribution of tourist accommodation units displayed on Booking.com. This manual geolocation and selection process ensured that only tourist accommodations located strictly within the park's administrative limits were identified and included in the analysis. From this initial list, we narrowed it down to 10 accommodations, namely those that claimed to follow at least one sustainability practice. This was achieved by looking up to all the indicators supplied by Booking.com (Table 1) for each of the units. To ensure the anonymity of the results, a random code, from H1 to H10, was assigned to the tourist facilities, previously presented in random order. The analysis of sustainability practices for each accommodation unit was done

by awarding the value of "1", if the indicator was mentioned on the platform, and "0" if absent.

Table 1. Sustainability indicators considered by Booking.com

Category	Sustainability practice
Waste	Recycling bins available to guests and waste is recycled
	The property makes efforts to reduce their food waste
	Single-use plastic stirrers not used
	Single-use plastic straws not used
	Single-use plastic cups not used
	Single-use plastic water bottles not used
	Single-use plastic bottles not used
	Single-use plastic cutlery/plates not used
	Single-use plastic miniature shampoo, conditioner, and body wash bottles not used
	Water cooler/dispenser
Water	Water-efficient toilets
	Water-efficient showers
	Option to opt-out of daily room cleaning
	Option to reuse towels
Energy and greenhouse gases	Most lighting throughout property uses energy-efficient LED bulbs
	All windows are double-glazed
	Key card or motion-controlled electricity
	Electric car charging station
	100% renewable electricity used throughout
	Offsets a portion of their carbon footprint
	Most food provided at the property is locally sourced
Destination and community	Invests a percentage of revenue back into community projects or sustainability projects
	Tours and activities organised by local guides and businesses
	Local artists are offered a platform to display their talents
	Provide guests with info about local ecosystems, history, culture, and visitor etiquette
Nature	Wild (non-domesticated) animals are not displayed/interacted with while captive on the property or harvested, consumed, or sold
	Green spaces like (rooftop) gardens at the property
	Most food provided is organic
	Bicycle rental
	Bicycle parking

Source: Booking.com (January 2023)

The second stage of research aimed at producing a simplified approach to assess the sustainability practices of PNSAC accommodation units which will enable stakeholders to continuously improve ranking while informing the tourists in a symbolic three-colour level way. In this regard, the total was then calculated using an evenly weighted

score awarding each category the maximum of 5 points independently of the number of indicators present and classified using the score intervals (Table 2). The total score ranged from 0 to 25, derived from five categories, each worth a maximum of five points, and was logically divided to create intuitive colour-coded categories: Insufficient (<15), Adequate (15 to 20), and Optimal (>20). The thresholds for the sustainability score categories were established through a pragmatic choice to create a balanced, three-tier classification system that is easily understood by stakeholders and tourists.

Table 2. Score rank classification limits

> 20	Optimal
15 to 20	Adequate
< 15	Insufficient

Calculations were made considering k as the number of "Categories", defining C_i, $i = 1, \cdots, k$, where C_1 stands for *"Waste"*; C_2 stands for *"Water"*; C_3 stands for *"Energy and greenhouse gases"*; C_4 stands for *"Destination and community"*; and C_5 stands for *"Nature"*.

For each "Category", Booking.com defines "General Indicators", represented by $G_{i,j}$, $i = 1, \cdots, k$ and $j = 1, \cdots, h_i$, where h_i expresses the number of General Indicators for each Pilar. In our case, $h_1 = 10$, $h_2 = 4$, $h_3 = 7$, $h_4 = 4$ and $h_5 = 5$.

Therefore, $G_{1,1}$ was defined as the 1st General Indicator *of the 1st* Category *"Recycling bins available to guests and waste is recycled"*; $G_{1,2}$ as the 2nd General Indicator of the 1st category *"The property makes efforts to reduce their food waste"*, and so forth, till $G_{5,5}$.

As mentioned, each accommodation unit in the study was coded according to the presence or absence of the General Indicator in each Pilar, by 1 or 0, respectively, i.e.,

$$\left\{G_{\{1,1\}}, c..., G\right\}_{\{5,4\}} =$$

$$1 \text{ presence of General Indicator } j \text{ of Pilar } i$$

$$0 \text{ absence of General Indicator } j \text{ of Pilar } i$$

U was defined as the maximum score possibly attained ($U = 25$). A shift was necessary in order to get the maximum score if all the General Indicators were present in all Categories. The shift was equally applied to the mean number of the General Indicator's presence in each category, by a factor that was proportional to the number of the General Indicators for each Category.

So, taking $T_G = \sum_{i=1}^{k} h_i$ as the total number of General Indicators, the factor for each Category was given by:

$$F_i = U \times \frac{h_i}{T_G}, i = 1, \cdots, k$$

We represented each observation unit as $O_{m,i,j}$, $i = 1, \cdots, k$, $j = 1, \cdots, h_i$, $m = 1, \cdots, n$, where n represents the number of establishments (10 hotels in our case).

To achieve the final score for each accommodation unit, the formula was:

$$S_m = \sum_{i=1}^{k} \sum_{j=1}^{h_i} \frac{O_{m,i,j}}{h_i} \times F_i$$

and it was further ranked according to the following classification:

$$S_m \geq 0,8U \Leftrightarrow S_m \geq 20 \text{ optimal}$$

$$0,6U < S_m < 0,8U \Leftrightarrow 15 < S_m < 20 \text{ adequate}$$

$$S_m \leq 0,6U \Leftrightarrow S_m \leq 15 \text{ insufficient}$$

The simple, integrative design of the proposed ranking model ensures replicability in other contexts, with the possibility of adjusting the scoring method to include additional or context-specific indicators. This approach aligns with the broader academic literature in tourism and sustainability, which often favours simplified, expert-informed frameworks over complex, purely data-driven models (Leite et al. 2022, Marinello et al. 2023). Also, this methodology prioritises clarity and practicality, reflecting the trade-off between academic rigour and the need for effective public communication, a common practice in this field, as evidenced by studies from Tanguay et al. (2011), Glyptou (2022), and Marinello et al. (2023).

The third stage of the study involved a more in-depth perspective, investigating how the representatives of the 10 tourist accommodations that display sustainability claims in their Booking.com profile perceived sustainability in general and the liaison that they have with the PNSAC authorities, meaning how they interact with them to foster sustainable tourism. In other words, it aimed to understand sustainable behaviours in practice and attitudes towards the environment and responsibility regarding the protected area status, which are considered in the literature as core values of sustainability (Peng Xu et al. 2012, Wondirad and Ewnetu 2019, UNWTO 2022, Faraji Vaghaslo et al. 2024, OECD 2025).

The in-depth semi-structured interviews with the accommodation units' owners/managers were designed following a funnel approach (Dunn 2021), gradually moving from general information about the business to specific topics related to sustainability and their interaction with the protected area authority.

To establish a meeting with the owners/managers of the accommodation units, initial contatct was attempted via the phone numbers from Booking.com. As in some cases telephone meeting proved unsuccessful, we visited the locations directly. The purpose of these interviews was not to verify if the self-reported sustainability practices were actually implemented but rather to understand the owners' perceptions and experiences of running an accommodation unit within PNSAC.

The interviews began with questions on the business history and its current features. They then explored perceptions of operating within a natural park and their commitment to sustainable tourism. This included accommodation providers' interactions with NPA authorities as promoters of this activity, their frequency and types, as well as the nature of their communication and collaboration. Furthermore, the opinions on areas for improvement were investigated. Additional questions addressed other aspects, such as the primary tourist attraction of the area, relationships with other local businesses, and plans.

Open-ended questions (Valentine 2005) were used throughout to allow interviewees to describe their experiences in their own words, while more specific follow-up questions were posed when further detail was needed (Glaser and Strauss 2017). Each interview was conducted on-site face-to-face, and it lasted between 50 and 90 minutes. To ensure accuracy in data collection, the interviews were audio-recorded with the participants' consent.

After completing the interviews, all audio recordings were transcribed verbatim and systematically reviewed multiple times to ensure accuracy with the content. Each interview was coded with a unique identifier consisting of the interview number followed by the term "case" (e.g., case 1 corresponds to interview number 1).

The fourth stage of research focused on the content of stakeholders' narratives, based on analysing the interview transcripts several times, individually and then comparatively. Also, the responses were clustered into key thematic categories. These categories reflected recurring ideas across the interviews and included: their journey towards sustainable tourism; the shortcomings concerning the interaction between accommodation providers and PNSAC authorities in promoting sustainable tourism; as well as suggestions for improvement. This thematic organisation facilitated a structured interpretation of the collected data and it supported the identification of common patterns and divergent viewpoints among the interviewees.

To emphasise the shortcomings/suggestions for improving the liaison between the stakeholders and the PNSAC authority, two-word clouds were designed. Text analytics was used to interpret a large amount of unstructured text into qualitative data (Lakshmi and Baskar 2021), while its fusion with visualisation tools of frequently used words provided a deeper understanding of interview insights (DePaolo and Wilkinson 2014, Ren and Han 2016).

Results

Only 33.3% of the total number of PNSAC accommodation units registered on Booking.com reported sustainability practices (Figure 3). Overall, it was found that some of these practices were frequently implemented (such as: *Recycling bins available to guests and waste is recycled*; *Water-efficient toilets*; *Option to opt-out of daily room cleaning*;

Option to reuse towels; *Green spaces like (rooftop) gardens at the property*), while others were reported to be implemented by only one accommodation unit (such as: *Water cooler/ dispenser*; *Electric car charging station*).

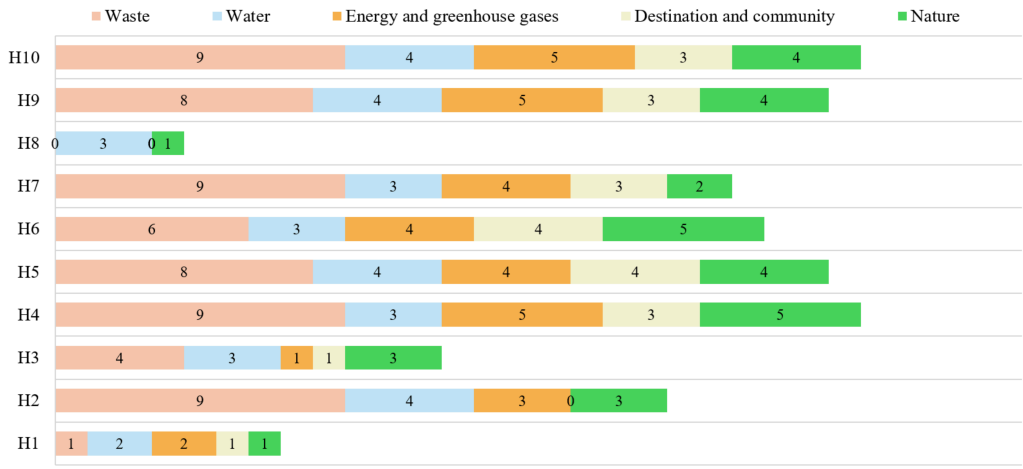

Figure 3. Score calculation for Booking.com "Sustainability" indicators. Source: Booking.com (January 2023) processed data

Water was the most popular category, including three of the most widely adopted practices mentioned above. While these measures are environmentally ethical, they also bring economic benefits, such as reduced water charges and lower cleaning expenses.

Waste and *Nature* were the following two categories in the hierarchy of sustainability practices. Regarding the first one, six of the ten tourist accommodations implemented eight, at most nine practices, demonstrating a high commitment to waste management. This could be partially related to the municipality's effort to implement recycling measures. In contrast, H8 did not implement any measures of this kind, while H1 only had one practice in place. However, looking closer into the indicators used by Booking.com to award this sustainability class, one may find that most indicators (7 of them) were related to the European Union legislation measures to reduce the use of plastic.

The most difficult practices to implement for *Nature*, as done by only half of the tourist accommodations, were the following: *Most food provided is organic*, and *Bicycle rental*. At the same time, almost all units reported to have *Green spaces*, as they were closely correlated with the natural setting in which they were located.

Within the *Destination and Community* category, eight of the accommodations found it relatively easy to *Provide guests with info about local ecosystems, history, culture, and visitor etiquette*. This demonstrated the hosts' hospitality and their willingness to share insights about the local context.

Practices related to the *Energy and Greenhouse Gases* class were generally the most difficult to adopt. However, eight accommodation units had successfully implemented two measures: *Most lighting throughout property uses energy-efficient LED bulbs,* and *All windows are double-glazed*. On the other hand three practices were among the least frequently adopted. Specifically, only one establishment offered an *Electric car charging station*, two establishments had *Offset a portion of their carbon footprint*, and three of them reported using *100% renewable electricity used throughout the year*.

The final score for sustainability practices ranking (Figure 4) indicated that 40% of the tourism offers were insufficiently implementing sustainability practices, particularly concerning H8 and H1, scoring 4.8 and 6.7, respectively. In general, they were characterised by the implementation of the easiest measures, which were also linked to cost savings (e.g. related to Water class, *Recycling bins available to guests and waste is recycled*). Another 40% of the units fell into the optimal category, while the rest belonged to the adequate category. However, none of the units implemented all sustainability practices. It was clear that while some accommodations were deeply committed to sustainability, others were just beginning to adopt these measures.

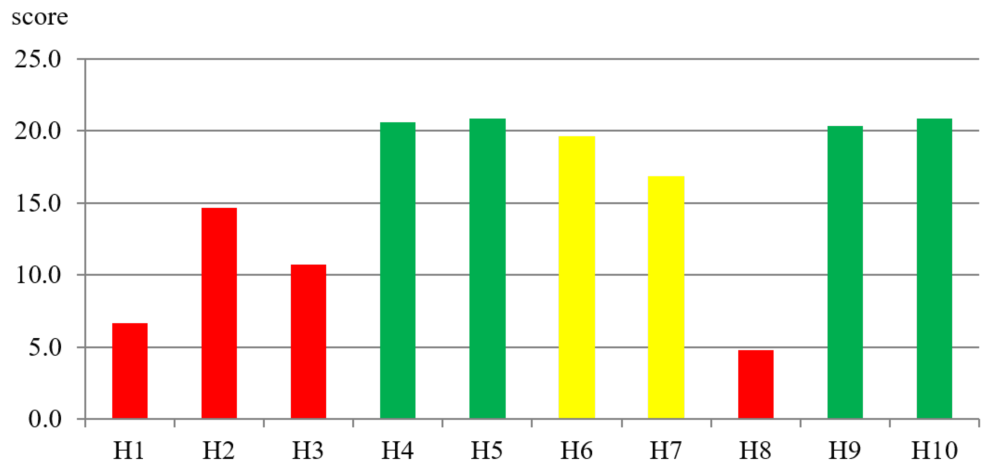

Figure 4. Final sustainability practices ranking score for each PNSAC accommodation unit

The interviews with representatives of the ten tourist accommodation units that promoted sustainability practices within PNSAC revealed that all of them were small businesses, reflecting the range of tourism activities in the area.

The first accommodation was established in 2004, with the others opening after 2011, indicating a significant increase in the PNSAC tourist activity in recent years. Data from ICNF (2024b) confirmed this evolution: the number of recorded visitors increased from 5,008 in 2004, to 49,591 in 2024, despite some annual fluctuations, with the most significant rise occurring after 2013. However, it is important to note that this data

provided only a general overview of the trend, as it only accounted for the number of visitors to the facilities, and the tours/events that they organised.

One respondent even noted that his hotel was the village's first accommodation option, and then others followed. In this context, some of these units promoted tourism activities in the area, leading other entrepreneurs to open additional small accommodation facilities.

Regarding their general perception of sustainability, the majority of respondents showed a clear trend towards developing their activities in harmony with nature, embedded into the local mountain environments. This was reflected in the thematic names of some accommodation structures, which included terms like "serra" (meaning mountain), and terms like "retiro", "refugio", "bosque", and "serena", meaning *retreat*, *refuge*, *forest*, and *serene*, respectively. This approach was rooted in the fact that "people were looking for exactly these places without a lot of development. Peaceful, quiet and located in nature" (case 2), thus based on the attractiveness of natural resources.

The facilities are striving to create appealing and niche concepts, some of which were associated with art or yoga, or they were focused on tranquillity. Additionally, during the COVID-19 pandemic, the potential of central Portugal was rediscovered, and PNSAC accommodations considered that they had an advantage because people felt drawn to wilder places. Consequently, they were committed to preserving the natural features which attract tourists to support sustainable tourism.

The interviewees generally perceived sustainable tourism as a concern to implement as many measures as possible, either now or in the future. Some approaches even drew on traditional local systems that promote sustainability practices, such as rainwater harvesting. One interviewee described this technique as "the old ecological system that worked perfectly" (case 4). In this limestone region, known for its water scarcity, rainwater harvesting was a common ancient method used by many people to secure an adequate water supply.

Some of those interviewed grew fruit and vegetables, expressing their concern for providing organic food. Additionally, a local economic ecosystem was emerging, where local products were highly valued and mutual support was encouraged through the purchase of food, handicrafts, or the promotion of local services. One interviewee described this situation as a reflection of the region's traditional culture, stating: "it's the normal trading characteristics of the region" (case 2).

It is important to note that the implementation of certain measures relied significantly on national-level policies, such as the availability of funds for installing solar panel systems. In this sense, one of the interviewees emphasised: "now, everything also depends on what we do, and on how we get financed" (case 6). In other words, if they wanted to become greener, they could propose projects, but it also depended on what funding possibilities existed at the national level.

The shortcomings identified by the tourist accommodations providers of tourist accommodations (Figure 5), in terms of their connection with NPA authorities and the latter's contribution in supporting their efforts for sustainable tourism in the area, included: the nature of the interaction; its broader implications; the impact of current environmental protection regulations; the state of the infrastructure; and the engagement with other stakeholders, such as local associations.

Figure 5. Word clouds with (a) shortcomings, and (b) suggestions for improvement, regarding the stakeholders' interaction with PNSAC authorities to promote sustainable tourism

Nonetheless, the most frequently mentioned issue was the lack of interaction with the PNSAC representatives, with whom they had "no contact", "no collaboration", and "no communication". As a result, the PNSAC administration was considered to be "inactive" (case 3), "quiet" (case 6), and "indifferent" (case 2).

The situation was also linked to the fact that there were "no activities" in common with the PNSAC authority (case 6), and "effectively, the park does not create alternatives to bring business closer to the park. It's, in fact, the opposite" (case 1). Consequently, there was the perception that "the NPA authority does not really pay much attention to the businesses at all" (case 2). Overall, they did not feel supported by the PNSAC authority in fostering a sustainable development of their business, enhancing the attractiveness of the area, or its promotion. Some have even noted that the local municipalities "will help them to promote the business rather than the park" (case 8).

However, it should be emphasised that one person indicated some ad hoc communication with the PNSAC administration in certain situations, especially when they asked permission for something, i.e. to cut down trees (case 1). This communication, anyway, was not initiated by PNSAC employees but rather by the stakeholders them-

selves. Another respondent described a change in the attitude of the PNSAC authority, as before the pandemic: "they used to communicate... Maybe once a year or so they held/promoted meetings with the accommodation facilities in the region, but after the pandemic, they did not do it anymore. There is no support whatsoever" (case 6).

Regarding the possible reasons for this decrease in interaction, one respondent suggested that it might be related to the institution's budget, noting the "probability of not having money" (case 3). Others attributed the lack of engagement to the fact that "the NPA management has a specific nature conservation orientation" (case 5).

Amid this perceived lack of interest, entrepreneurs had expressed their concerns regarding the area's physical infrastructure. They described it as being "degraded", noting issues such as "the bike trails are completely destroyed by wild boars" (case 7), "the signs are not well-maintained" (case 3), and "the paths are not properly organised, and resources are not clearly indicated" (case 4). These issues were significant because they portrayed "a bad image of the park. It is a bad business card. It is like saying everything is abandoned" (case 3). From a business perspective, there was concern that tourists might feel disappointed and choose not to revisit the area or might share negative feedback.

In the same line of thought, another interviewee mentioned the lack of PNSAC visibility, indicating insufficient information regarding the natural park in the territory for tourists. In this context, another respondent wondered rhetorically if this situation was somehow intentional, suggesting that "tourists can do pretty much anything; I don't know if they are scared of what excessive tourism can create" (case 1). This highlighted that the lack of communication led to different assumptions and to possible misunderstandings of the PNSAC authority's position.

Three respondents noted that the existence of rules, described as "very strict" (case 3), was a significant shortcoming for their business. In particular, the restrictions on constructing new houses and on obtaining building permits (case 2) were problematic. As a result, old houses were usually renovated/rebuilt for these reasons.

One shortcoming identified by the respondents involved a conflict among various activities permitted within the natural park. For instance, practices—such as animal grazing and the clearing of overgrown bush for forest fire prevention—clash with hunting and the installation of wind turbines. This conflict was further complicated by the differing views among the local parishes. Additionally, there was a lack of connection with the local associations which were involved in the initiatives relevant to the PNSAC authority. Unfortunately, these associations did not receive any support. Some of these initiatives also included volunteer efforts to remove the rubbish from the forest or to clear invasive species, involving the representatives of the tourist accommodations (case 6).

Further, most interviewees emphasised the need to collaborate with the PNSAC authority to support their businesses and to further promote sustainable tourism. In

this respect, it was noticeable that some of them talked about collaboration in general, while others pointed to particular topics, such as landscape monitoring and maintenance, enhancing knowledge, advertising, managing forest fires, and engaging local stakeholders.

Firstly, the stakeholders recognised the necessity of working together to promote the area, as the PNSAC authority served as "the face of the park in terms of tourism" (case 6). The interviewees indicated that businesses in the area only undertook individual advertising efforts, which they believed to be insufficient and that a more integrated approach was necessary. In this sense, there should be a concern at the institutional level to "create mechanisms to make people look for the NPA" (case 1). Such initiatives should aim to promote PNSAC, both within its boundaries and externally, to attract more tourists.

Furthermore, one respondent noted the potential benefits, highlighting that increased funding could be used to "better preserve the park structure" (case 1). One notable aspect was that some respondents clearly stated they would like to contribute to nature conservation, "but they don't know how" (case 2), and therefore proposed educational support from the PNSAC authorities. In the same vein, others believed that the PNSAC representatives "should work more with the businesses... and they should inform them about the regulations in force" (case 3).

Another suggestion focused on the need for support in monitoring, controlling, and prosecuting activities related to forest fires, alongside with "NPA maintenance" (case 1). This included vegetation management and land clearing to prevent fires. Another addressed topic that required PNSAC intervention was trail maintenance to support outdoor tourist activities.

Overall, the necessary collaboration with the PNSAC authority was perceived from a multi-level stakeholder perspective, first with the accommodation establishments, but also with the local authorities and population, towards the same common goal of promoting sustainable development in the area. Thus, they believed that the PNSAC authority should support diversifying the tourist offerings, such as establishing an interpretation centre and exploiting water resources through a water park near the lake. These initiatives could attract more tourists, and encourage them to spend additional time in the area (case 2).

In the same line of thought, the PNSAC authority should consider the local population by encouraging their involvement in promoting less-known local attractions and by supporting the selling of local products. This approach would help to foster the growth of local businesses and to enhance tourism overall.

As far as the local authorities were concerned, the PNSAC administration was perceived as a potential catalyst to bring stakeholders together and to establish a common vision for the controlled sustainable development of the whole area. This was motivated, on the one hand, by the fact that these structures overlapped on the same

territory and, on the other hand, by the fact that some activities were carried out with the agreement of the PNSAC authority, but were then implemented differently by the municipalities, which led to dissensions.

In the absence of collaboration with the PNSAC authority, some entrepreneurs in Alvados were seeking to work together on an integrated project for tourism development in the area. They hoped to gain support from the parish mayor; however, this initiative was limited in scope, addressing only a small fraction of the broader area under consideration.

Discussion

Our results indicated that the percentage of PNSAC accommodation units listed on Booking.com which report sustainability practices remains surprisingly low. To address this, it is essential to inform tourists and to encourage the accommodation providers to adopt more sustainability measures and to communicate it. A notable limitation of Booking.com is that, despite being one of the world's most widely used online tourist platforms, it does not include all available accommodations in the area, and it primarily presents predefined sustainability practices without allowing for additional specific information. This observation aligns with previous research findings underlining that booking platforms have only partially integrated sustainability considerations (Arzoumanidis et al. 2022).

Furthermore, for some indicators, there is very little control, as it is extremely difficult to determine, for example, if all the electricity comes from renewable sources, or if the food is locally sourced. Therefore, Booking.com trusts that the owners/managers of tourist accommodation understand the sustainability concept and respond accordingly.

Despite these shortcomings, the results align with other studies which highlighted that using Booking.com data allows for an integrated analysis of sustainability actions adopted in large areas (Rutecka et al. 2025), and of the recorded progress. By comparison, various studies revealed that, on their websites, the accommodation units present only some sustainability actions, or they do not present them at all, even though they exist in place (Khatter et al. 2019, Pato and Duque 2021); or many hotel chains generally present the measures taken but without specifying in which location they apply them (Mota et al. 2024). As a result, using information on their websites makes the analysis very difficult to achieve and time-consuming.

In terms of the final sustainability practices ranking score, any result below "optimal" should be considered unsatisfactory. This is crucial since we need to strike a balance between nature preservation and tourism activities when discussing NPAs. It is also worth noting that using a more comprehensive set of indicators would enhance this assessment, benefiting both the user information and the conservation interests.

The indicators currently employed by Booking.com are generic and applicable for any facility worldwide. However, the question here is whether this platform should recognise the operating tourist accommodations inside protected areas and if they should also implement specific indicators that reflect their contribution towards nature preservation. Technological advances and the use of apps and online platforms, despite offering to customers better information and fairer competition between businesses, still have a long path ahead before they can adequately contribute to the comprehensive implementation of sustainability, especially in NPAs.

Most sustainable measures provide some form of economic benefit to the accommodation units, as noted in other studies (Chan 2013, Reem et al. 2022, Ray et al. 2023). However, they also contribute to more efficient use of resources such as water or energy (Mota et al. 2024). Our results mirror previous studies indicating that, in various places, only a small number of accommodation units report online sustainability measures (Foris et al. 2020, Arzoumanidis et al. 2022).

Regarding the implemented practices, our results are partially consistent with those of Rutecka et al. (2025), who used data from Booking.com to analyse tourist facilities in Poland, and they found that the most commonly applied practices include *recycling bins available to guests and waste is recycled,* as well as *water-efficient toilets*. Overall, it can be observed that the most popular measures fall within the water and waste categories, although those in the latter group are significantly more frequently enforced in the aforementioned study compared to the PNSAC. Still, there are notable contrasts, such as the practices *provide guests with info* and *green spaces like (rooftop) gardens*, which are among the least implemented in Poland, whereas the situation is the opposite in the PNSAC. Additionally, while the most implemented practices in the *Energy and greenhouse* category in the PNSAC include *uses energy-efficient LED bulbs*, and *all windows are double-glazed*, the comparative study highlighted that *electric car charging station* is often available in Poland. Conversely, this particular measure is reported by only one facility within the PNSAC. These findings suggest that the adoption of certain practices is deeply rooted in the overall local setting, as supported by previous research (Renfors 2021).

Regarding the particular situation of NPAs, previous studies have used questionnaires to assess sustainability-related measures (Erdogan and Tosun 2009, Silik et al. 2023, Font et al. 2016). As a result, the data collected are only partially comparable due to the variability in the gathered information. However, our findings partially align with research by Font et al. (2016) focused on 57 NPAs in Europe. Based on information collected from over 900 tourism enterprises, it indicated that many enterprises implemented measures related to water and energy savings, as well as to waste recycling.

In contrast, two other studies that examined environmental performance in accommodation establishments—one in a National Park (Erdogan and Tosun 2009), and another in 16 NPAs in the province of Bolu (Silik et al. 2023), both in Turkey—found that

few practices related to *waste reduction*, *water and energy efficiency*, and *providing guests with information about the environment* were being implemented. However, Erdogan and Tosun (2009) noted two exceptions: *water-saving measures for linen changes*, and the *use of energy-efficient LED bulbs*, which were slightly above the average level recorded. These findings highlighted that the implementation of sustainability measures is also linked to enforced policies. Additionally, the adoption of many practices often involves additional costs, requires specific knowledge and necessitates support from authorities or the representatives of NPAs.

In promoting sustainable tourism, there is a significant gap between the vision outlined at the national level, by the Portuguese National Tourism Strategy 2027 (Turismo de Portugal 2017), at the regional level, by the PNSAC Co-Management Plan 2024-2027 (PNSAC 2024), and with the reality perceived by the stakeholders. Both strategic documents advocate for attracting tourists to protected natural areas, sustainable planning of tourism activities, and effective communication.

However, the stakeholders have indicated a lack of commitment from the PNSAC authority, highlighting a distant, institutionalised approach to park management, lacks proximity and effective governance. This does not imply that the PNSAC representatives are indifferent to sustainable tourism or that they lack certain measures; rather, it suggests that there is insufficient active collaboration with the stakeholders. As a result, being located within a NPA does not necessarily provide stakeholders with more information or support regarding sustainable tourism compared to those in other areas. Instead, this overarching structure leaves stakeholders feeling somewhat in the dark regarding their expectations.

Tourism stakeholders and the PNSAC authority appear to be two distinct groups of actors, each pursuing its own objectives. This confirms the results of previous studies which indicated that sustainable tourism development in protected areas involves various stakeholders with different interests (Ianos et al. 2012, Mitrică et al. 2021, Renfors 2021, Sørensen and Grindsted 2021). Also, several studies highlighted the stakeholders' dissent regarding the lack of collaborative structures between various public and private actors in other NPAs around the world (Pallarès-Blanch 2009, Tulla et al. 2017, Silva et al. 2023). This situation is considered a significant challenge, and has proven to be inefficient (McCool 2009). However, these stakeholders should collaborate, as they operate within the same area and the tourism's potential negative impacts can lead to natural and cultural heritage degradation. At the same time, it is essential to establish strategies to support sustainable tourism to benefit local communities by creating multiple opportunities, and favouring the reduction of territorial imbalances (FAO and UNWTO 2023).

These stakeholders play a crucial role in the preservation of natural resources through the measures which they implement within the PNSAC tourist establishments, as well as their ability to encourage tourists to engage in sustainable behaviours. This

can be done by guiding the visitors towards sustainable activities in the area and by informing them about environmental protection.

Previous studies advocated for conscious tourism and they highlighted the importance of hosts in shaping how tourism is practised at the local level (Coll-Barneto and Fusté-Forné 2023). Moreover, somehow, the situation is on the edge because the development trend of tourism activities is upward, and the lack of communication can jeopardise the practice of sustainable tourism, so a paradigm shift is needed. This concern is particularly relevant because this study focuses only on stakeholders who have publicly committed to sustainability practices on Booking.com. At the same time, we lack information on the measures taken by other tourist facilities.

The tourism providers view the PNSAC authority as a reliable institution, a possible facilitator between different local public or private actors, being able to build an appropriate territorial planning tool, and pursuing a unified vision for promoting sustainable tourism. This result is in line with the findings of other studies (Wondirad and Ewnetu 2019, Trišić et al. 2022, Ginting et al. 2024), suggesting that sustainable tourism in protected natural areas requires participatory planning, that involves consultation with local stakeholders (Lourenço et al. 2009, Buongiorno and Intini 2021). Additionally, collaboration among different public and private stakeholders is generally deemed essential for sustainable development in mountain regions (FAO and UNWTO 2023).

Evidence from recent studies (Silva et al. 2023,Ferretti-Gallon et al. 2021,Sørensen and Grindsted 2021) suggested that effective collaboration between NPA administrations and local stakeholders depends on integrating effective participatory mechanisms into governance and on ensuring that conservation efforts generate clear socio-economic benefits for the local communities. In practice, this involves: establishing multi-stakeholder platforms (formal committees or councils bringing together local authorities, tourism operators, NGOs, and community representatives) to jointly shape the visitor management, tourism products, and conservation priorities (Stokke and Haukeland 2017, Vijulie et al. 2024); adopting adaptive policy tools by engaging local businesses and destination marketing bodies in the creation and the revision of measures, such as access regulations, so that environmental objectives are aligned with economic sustainability (Smith et al. 2024); building legitimacy-based partnerships through co-developed branding, marketing, and product design with sustainable entrepreneurs, strengthening both the park's conservation image and the competitiveness of local enterprises (Dawo et al. 2023). Implementing these approaches can transform stakeholder engagement from occasional consultation into durable, mutually reinforcing governance, where ecological integrity and community prosperity advance together.

This study has several limitations that should be noted. Not all accommodation units in the PNSAC are listed on Booking.com, and despite our efforts, we were unable to find an integrative source publicly available. The measures claimed by the tourist

units with at least one declared sustainability practice have not been verified on-site. Then, the research focuses on a single NPA and a single category of stakeholders in an exploratory approach tailored to the local context of the PNSAC, which somewhat limits the generalisability of the results.

However, this research enriches the current literature on sustainable tourism in NPAs by offering insights into the perceptions of accommodation providers and the sustainability practices they have implemented from a comprehensive perspective. Furthermore, developing an effective sustainable tourism strategy requires a deep understanding of local characteristics and challenges (Silva et al. 2024), along with an awareness of the perceptions of various stakeholders (Heslinga et al. 2019). Given the limited research on PNSAC, our findings can provide valuable insights for management and local authorities, regarding key aspects that tourism providers consider essential for sustainable tourism. In this regard, to the best of our knowledge, this is the first study of its kind in the analysed area.

First, the findings from the interviews alerted to and highlighted the necessity of implementing a new approach, implying a close relationship between the accommodation providers and the PNSAC authority and other stakeholders to support sustainable planning for this region. Secondly, the proposed sustainability ranking score allows for a quick and integrative analysis, acting as a clearer customer information tool that is useful for setting a hierarchy and generating an overall assessment of a given area. This approach contributes to raising awareness among stakeholders of the need to implement more measures on their path towards sustainability, while also providing concrete directions for improving sustainable tourism governance and practice within the PNSAC. The ranking tool offers the PNSAC administration, local policymakers, and tourism operators an accessible method to assess and compare accommodation practices, while enabling targeted interventions where sustainability performance is low.

Future research could extend the analysis to other contexts in order to understand the degree of implementation of sustainability practices and to gain more insights supporting sustainable tourism development.

Conclusions

The analysis on the Serras D'Aire and Candeeiros Natural Park, Portugal, highlighted that only one third of tourist accommodation establishments engaged in at least one sustainability practice. The findings of this study are relevant because they demonstrate how data from one of the most popular online booking platforms can be utilised to analyse the sustainability practices of tourist accommodations. This approach has only been explored to a limited extent in the scientific literature so far. Additionally, it further alerts us to the need for more sustainability indicators, particularly for establishments operating inside natural protected areas.

The proposed sustainability practices ranking score, designed to classify the tourist accommodations using a simplified approach of the data extracted from Booking.com, revealed that 40% of these tourist units fell into the "inadequate" category. This result indicates that, while implementing some green measures, they are still in the early stages of their journey toward proper sustainable tourism development. This tool can be used to analyse other areas too, deriving findings that can substantiate adequate sustainable tourism planning.

Additionally, the study results display new insights into the perceptions of tourism providers who reported sustainability measures on the online platform. The content analysis of the in-depth interviews revealed that the respondents are concerned about implementing sustainability practices. These outcomes are also linked to their awareness of being embedded in a local mountain setting that attracts tourists due to its natural and cultural resources, which they need to be preserved. Still, the information gathered from the interviews is particularly striking, especially given the lack of interaction with the PNSAC authority, as the promoter of sustainable development in the analysed area.

The accommodation providers felt unsupported in carrying out their business or in enhancing the area's attractiveness. The expectations from the PNSAC are manifold and they focus on several key areas. The stakeholders seek support and guidance on environmental protection, effective management of certain areas, maintenance of tourism infrastructure, and the development of new facilities to diversify the tourism offer, along with actions related to marketing. Most tourism providers appreciate that they can be more easily promoted in an integrated manner under the umbrella of the PNSAC, giving them a territorial identity. Consequently, the protected area status is seen as a valuable tool for the sustainable development of this mountain region, consistent with the outcomes of other studies (Mose 2016).

Tourism in PNSAC is still in its early stages compared to other regions. Still, in recent decades, a noticeable trend towards urbanisation within and around several protected areas in various parts of Europe, driven by the appeal of high-quality natural heritage, has been observed and known as a naturbanisation process (Lourenço et al. 2009, Prados 2009, Pallarès-Blanch et al. 2014, Calvache et al. 2016). In the PNSAC, as in other natural parks, the increase in the number of tourists and accommodation units serves as a clear sign of naturbanisation. The commodification of nature has led to the development of new economic activities and job opportunities, particularly in the tertiary sector (Prados 2009, Tulla et al. 2017, Barrado and Prados 2022). It is essential to manage all these changes carefully, considering the dynamics and key stakeholders involved, as their actions can either support or undermine nature conservation efforts (Calvache et al. 2016).

The stakeholders are open to dialogue, and feel the need for a permanent collaboration with the PNSAC authority, which they see as the only body that could coordinate

and guarantee a unified vision for sustainable tourism in the whole area. In this regard, the PNSAC representatives are viewed as bridge builders (Stokke and Haukeland 2017) who should facilitate dialogue among various public and private stakeholders. Still, it is noted that some of the expectations of accommodation providers towards the PNSAC representatives may exceed their responsibilities, which are related to the management of natural heritage and to taking measures to preserve it. The involvement and collaboration between the PNSAC authority, the local authorities and other relevant stakeholders seem more appropriate. Practical measures to achieve this include establishing regular stakeholder forums, co-developing marketing strategies to promote the PNSAC as a unified destination and providing educational support to tourism providers on environmental regulations and conservation practices. Finally, this cooperation may hold the key to sustainable development in protected areas, while educating and creating substantiated sustainable tourism through governance and collaboration.

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Aims & Scope

Urban and regional questions are crucial in understanding the present territorial conditions. From the World Bank's 'rediscovery' in its 2009 Report of the potential of cities in encouraging economic growth, to the multiple ways in which cities are being drawn into the processes of neoliberalism, to the dynamic growth of cities in the developing countries in Asia far out stripping the scale of cities in the older urbanized nations – everywhere there are signs of a rapidly changing urban condition. The same is true for the regions where 'old questions' of regional economic disparity and uneven development are being given a new twist as economic globalization impacts the national and local arenas.

JURA, the Journal of Urban and Regional Analysis, working as an Open-access journal (with two issues/year, in **April and in October** - starting with 2023; previously annually publishing in June and in December, for the period 2009-2019), was launched as a response to the exciting world of urban and regional research emerging in reaction to these changes happening in the real world.

JURA represents the initiative of the Interdisciplinary Center for Advanced Research on Territorial Dynamics (CICADIT) at the University of Bucharest working in collaboration with Ronan Paddison at the University of Glasgow, for the period 2009-2020. Starting with 2021, JURA is also supported by the Professional Association of Romanian Geographers (APGR). While the intention is that articles published by JURA will draw on examples throughout the world, particular emphasis will be given to urban and regional change as it is being experienced in Eastern Europe.

Transitional economies, and urban and regional shifts in the region since the end of the socialist regimes have been profound. The socialist regime had its particular effects on the regional economy and the cities, linked with structures that, in many ways, were very different from the trends apparent in Western Europe in the post-World War II period. Since 1990, change has been swift, challenging our theoretical understanding of the processes; for example, it is plausible to transport theories of contemporary urban change under neoliberalism developed in the advanced economies to the transitional economy. The legacy of the socialist regime, its imprint on the city physically and socially, provides further reason to suppose that urban (and regional) development in transitional economies is distinctive. These differences re-emphasise a consistent axiom underpinning the study of cities and regions: that if it is possible to point to broad theories that apply across different regions of the world, they often need to be modified taking into consideration the local conditions.

Though JURA is primarily concerned with looking at urban and regional change in the transitional East European economies, case studies exploring similar problems but in other parts of the world are certainly parts of the journal's agenda. The remit of the journal is emphatically interdisciplinary. The analysis of the urban and regional conditions needs to be interdisciplinary. Urban and regional researchers usually tend to belong to a discipline reflecting their training whether as sociologists, geographers, urban planners or any number of subjects concerned with the study of space and place. Our training very often endorses an appreciation of how other disciplines explore the city and the region. For the journal, the acknowledgement of the many disciplines that are concerned with understanding cities and regions will be indicated by the different disciplinary backgrounds reflected in the published papers. Articles will be published by geographers, sociologists, urban planners, economists, political scientists, to mention just a few of the scholars involved in the urban and regional study.

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